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NOTICE.

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GNATS, MIDGES AND MOSQUITOS.—II.

By E. A. Butler.

As already intimated, Gnats and Mosquitos are amongst that section of the "thread-horned" flies whose early life is aquatic, and a truly remarkable history is theirs. That creatures so fragile should have at any time any connection with so unstable and treacherous an element as water is indeed strange, and unquestionably large numbers perish through the mischances involved in this very association; nevertheless, so great is their fecundity that the race runs no risk of extermination, notwithstanding the dangers that beset the path of the individual in its advance to maturity. The eggs are long oval objects, and from the time of laying they are entrusted to the water. The female, when about to lay, rests with her first pair of legs on some floating stick or leaf or other support, the second pair gently touching the water, while the third project over its surface. Crossing these like an X, she allows an egg to pass into the angle where they meet; this is soon followed by another and another, their moist and glutinous surfaces causing them to adhere to one another with the long axis nearly perpendicular. In this way a collection of some 200 or 300 is built up into the form of a tiny raft, concave above—a sort of miniature life-boat, so constructed that no capsizing can take place. The egg-raft once made, the maternal duties are over, and the little craft drifts rudderless away, exposed to sun and storm. This venturesome voyage, however, lasts but a few days, and then, the eggs having been from the first placed upside down in the water, the lower end of the shell is forced off, and the newly-hatched grub finds itself at once in position to take a header into the watery world in which it has to pick up its living.

These larvæ are odd-looking objects, foreshadowing the form of the adult to a somewhat greater extent than is usually the case with those insects which pass through a complete metamorphosis. The three regions of the body are distinctly marked out, quite the reverse of what obtains amongst the "short-horned" flies, whose shapeless "maggots" we described in a former number. If we imagine the full-grown Gnat's body to be bereft of all its long appendages—wings, legs, antennæ, and beak—and to be provided at intervals with tufts of hair instead, we get some idea of the outline of the larva. They move by a series of jerks, accomplished by swaying the body from side to side, and the natural position is head downwards. Though living in the water they inhale air, and hence come to the surface occasionally to breathe. The entrance to the breathing tubes is at the end of a sort of arm or branch jutting out from the hinder—*i.e.*, the upper—end of the body, and all that is necessary for taking in a fresh breath is to expose this little orifice just above the surface of the water. The larva is furnished with biting jaws, and spends a good deal of its time in devouring all sorts of rubbish and decaying matters, such as may be found in abundance in the pond it inhabits. Thus it swims about with tail most appropriately pointed to the sky, and head to the muddy bottom, where lie its chief stores of food.

It is easy to understand that thousands of these larvæ, working away in a pond on the decaying organic matter there, will do a good deal towards arresting the pollution of its waters, and Gnats, therefore, in this stage of their life may be regarded as sanitary agents, of more or less use to society at large. It follows, then, that their extermination from any district might not be altogether an advantage, unless accompanied by other changes, such as drainage, &c.; and in estimating the influence of Mosquitos, for example, in the economy of Nature, one has to set their services as scavengers over against the annoyance they cause by sucking blood. It might be a philosophical, if not very comforting, reflection for anyone suffering from the persecutions of these pests, that the more Mosquitos there are, the more scavenging work must have been done in bringing them to maturity, and the more must the sanitary condition of the country round have been thereby improved! There is another curious fact connected with this stage in the life-history of these insects; when fully grown, as we have already seen, they subsist only on liquid food, their mouth organs being excellently fitted for taking in liquids while they would find it absolutely impossible to make any use of solid food. But

in this earlier stage, the conditions are reversed ; solid food is the order of the day (though plentifully steeped in water, it is true), and no sucking apparatus exists, the mouth being armed with biting jaws instead.

The change, however, is not suddenly made from the one style to the other. There intervenes a condition in which the insect takes no food at all, either solid or liquid, having no available mouth; for, when several moultings of the jerky larva have taken place, it makes another change of skin which results in an entire upsetting of all its arrangements. After this moult it appears as a kind of animated "comma," with a big head and a curved tail. The apparent head is really head, thorax, beak, antennæ, limbs and wings of the perfect insect, all bound together under a thin skin, sufficiently transparent for the individual parts to be traced from without, as shown in the photographs last month; the "tail" is, of course, the abdomen, and it is terminated by a couple of broad leaf-like paddles (Fig. 2) of exquisite structure, which form a sort of sculling apparatus. It no longer jerks about head downwards, but, turning a somersault, passes the next stage of its life right way up, notwithstanding its apparently top-heavy shape. Conformably with the altered position, though whether as cause or consequence it is not easy to say, the opening to the breathing organs is now on the thorax. Two horn-like projections (Fig. 3) are here seen, which are the prolonged lips of the spiracles. Into these is taken, by periodical visits to the surface, whatever air may be necessary for breathing purposes ; such visits are, however, by no means frequent, the insect being capable of enduring prolonged submergence without inconvenience. The pupa is as capable of active exertions as was the larva, and in fact is freely locomotive, though it takes no food. This is a most exceptional circumstance amongst insects with a complete metamorphosis. Nothing, moreover, could be in stronger contrast to the style of life of the "short-horned" flies than that of this roving Gnat pupa. It will be remembered that the blow-fly, which may be taken as a type of the "short-horns," when about to become a pupa, does not cast its skin, but becomes a barrel-shaped, absolutely motionless body, by the hardening of the last larval coat, whereas the Gnat or Mosquito *does* cast its skin to become a pupa, and that pupa is a lively, wriggling creature, free to wander whither it chooses, though no more capable of feeding itself than the aforesaid barrel.

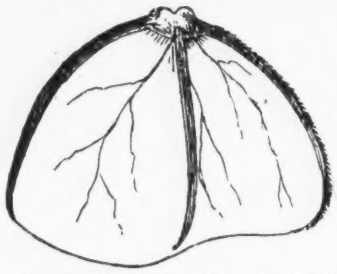

Fig. 2.—Terminal paddle or leaflet of pupa of a species of Gnat (*Corethra plumicornis*).

Fig. 3.—Spiracular horn of same Gnat.—*a*. Outline of thorax.

When the time for the emergence of the perfect insect arrives, which will be about a month after the hatching of the eggs, the pupa ascends to the surface, and, tipping up its tail, lies in a nearly horizontal position with the back of the thorax just above the water. The skin now splits, and the fly gradually extricates itself, of course in a limp condition and incapable of flight till its wings are dried and stiffened. The empty shell of the pupa gives it foothold till it is strong enough to spread its wings and mount into the air for the first time in its life. The occasion of the transformation from pupa to fly is evidently the supreme moment in the Gnat's career, and the risks involved are considerable. Not merely is it still exposed, as it has been hitherto, to the jaws of hungry fish or predaceous water insects, but there are also chances of wind and weather that may prove fatal. However, vast swarms escape these perils and rise into the air, where new dangers await them in the form of cobwebs and insectivorous birds, not to say human beings as well.

We have now followed our Gnat or Mosquito through a complete cycle of changes, and have thus seen that it is essentially an insect not of the house but of the pond, the marsh, and the swamp, whence it follows that blood-sucking is a practice that can but occasionally be indulged in, and it seems probable that great numbers of Gnats perish without ever tasting such food at all, and that in fact the habit is an acquired one and not really essential to their existence. If this be so, it is all the more remarkable when taken in conjunction with the extraordinary perfection of the blood-sucking apparatus, and the problem of their economy is as difficult to solve as that of the fleas on the sea-shore far from human habitations, to which we referred some time ago. Gnats, however, seem to be quite ready to drink the juices of flowers if they cannot get blood, and several observers have chronicled their fondness for honey. But still this will scarcely explain the presence of needle-like piercers amongst the mouth organs, since such instruments would not be necessary to get at the nectar of flowers.

In the days when every house had its water-butt, and when stagnant ponds abounded on every side, often in close proximity to human dwellings, the conditions were so much the more favourable for the multiplication of Gnats, and wherever such conditions now obtain, the insects are still likely to be both numerous and troublesome. But the extensive abolition of the water-butt, the introduction of closed and indoor cisterns, and the better drainage of the land, have all tended to throw hindrances in the way of the *Culicidæ*, and have helped to reduce their numbers in our own country, whatever may be the case elsewhere. There is evidence enough of this in literature. Enormous swarms of Gnats, of one kind or another, seem formerly to have been a not unusual experience, though such a thing now scarcely ever occurs here. The poet Spenser, for example, mentions as a familiar sight "a swarme of Gnats at eventide" that "out of the fennes of Allan doe arise,"

> "Whiles in the air their clust'ring army flies,
> That as a cloud doth seem to dim the skies":

and that *Culices* are intended seems certain, since they persecute man and beast

> "Till the fierce northern wind with blust'ring blast
> Doth blow them quite away, and in the ocean cast."

There are several records of swarms that have looked in the distance like clouds of smoke, and have consequently given rise to an alarm of fire, as was the case at Salisbury Cathedral in 1736. According to Prof. Riley, the northern Mosquitos of America pass the winter in the perfect state, hybernating in a semi-torpid condition, and a writer in *Insect Life* describes an enormous congregation of them as having been found hybernating in the corner of a cellar. This habit does not appear to hold good in all parts of the world.

A very peculiar connection between human beings and

Mosquitos has been made out in recent years. It is well known that there is a class of worm-like creatures, differing from the earthworm and other similar animals in not having the body divided into a series of rings, that inhabit various parts of the bodies of vertebrate and other animals. Man is subject to the attacks of several parasites of this sort, and shares them with other animals—*i.e.*, the parasites pass through their early life in the body of one host, and their later life in that of another. Numerous experiments and investigations, by Dr. Manson and others, seem to have proved that such a connection exists between man and a particular kind, or some few kinds, of Mosquito. The parasite is called *Filaria sanguinis hominis* (the thread-worm of the blood of man). The adult female of this creature inhabits the lymphatic glands of man, and is the cause of the curious and repulsive disease called elephantiasis, and of kindred maladies. Embryos produced from these sexually mature forms, pass from the lymphatic system into the blood of man and circulate with it, causing in this stage certain kidney diseases. No forms intermediate between these two have been found in man, and it is therefore evident that the intervening stages of the life of the parasite, whatever they may be, are spent elsewhere. From the blood of man, the embryos pass into the body of the Mosquito as it sucks its victim. Only a few of these seem to be digested with the blood; the rest escape from the Mosquito's digestive tube and establish themselves in its thorax, at the same time undergoing a change of form indicative of an advance in development. Thus far the history of the parasite has been traced, but exactly what happens afterwards is still to some extent a mystery. The Mosquito infested with *Filariæ* appears soon to die, the parasite apparently subsisting on the contents of its thorax. It has been thought that the Mosquito's body falling into the water on its death, the parasites escape and pass a free existence for a time, being after a while re-introduced into a human host by the drinking of the water that contains them. In investigating these facts, Dr. Manson got a Chinaman whose blood was known to contain *Filariæ* to sleep in a small curtained chamber placed in a larger room in which Mosquitos were flying. The door of the "Mosquito house" having been left open for some hours after the man had gone to sleep, was then closed, and the Mosquitos which had entered were thus entrapped. These were found in the morning clinging to the netting, gorged with blood, and were carefully collected day by day, and preserved; some were examined under the microscope at once, others not until after an interval, so as to secure a later stage of the parasite; in this way, by the examination of large numbers of the insects, after intervals of different length, the fate of the swallowed *Filariæ* was at length made out up to the point indicated above.

One of the most curious of the annoyances that have been recorded as occasioned by Gnats was illustrated in some specimens exhibited at a meeting of the Bristol Naturalists' Society in 1878. Mr. J. W. Clarke showed some sheets of writing paper from Sweden which formed part of a large consignment that had been greatly injured during the process of manufacture through a swarm of Gnats having got mixed up with the pulp. The remains of the flies were to be seen in the material of the paper, and some specimens were so perfect as to be easily identified as a *Culex*, and all seemed to belong to the same species. Another record is made of a Centipede similarly preserved in paper, and no doubt paper manufacturers could supply many others, though perhaps few on so extensive a scale as that alluded to above.

(To be continued.)

THE LIFE-HISTORY OF FILARIA SANGUINIS HOMINIS.

By Joseph W. Williams.

THE curious parasite, whose life-history we are about to relate, is found in the blood of persons suffering from a disease termed chyluria, which is characterized by the presence of chyle in the urine, and which occurs in certain tropical and sub-tropical countries, especially in Brazil, Mauritius, the Isle of Bourbon, Bombay, the West Indies, South Carolina, and Queensland. Cases now and again occur in Europe—one such came under my notice two years ago in a native of India—but, in the majority of instances, the persons affected have visited the tropics at some period of their lives. Five cases are, however, known to have occurred sporadically, and out of these two have been recorded in England—one in Lancashire, by Dr. William Roberts, and another in Norfolk, by Dr. Beale. The general range of the disease is within the limits 30° south and 30° north latitude. Probably, what is known as elephantiasis arabum—which must not be confounded with elephantiasis græcorum or leprosy—is also to be attributed to the presence of the same parasite.

This parasite has only been known to science in recent years. In 1866, Dr. Wucherer found several specimens at Bahia, in the urine of a patient suffering from chyluria, and two years later, Dr. Salisbury described, under the name of *Trichina cystica*, some worms which he had found in the urine of an insane person, and which now appear to have been nothing else than *Filaria sanguinis*. About the same time, Dr. Lewis of Calcutta, not knowing of Wucherer's discovery, called attention to observations that had been made by him of a similar character, and in 1872 he published that he had found nine specimens of the same kind of hæmatozoon in some blood which he had extracted from the finger of a Hindoo who was suffering from elephantiasis arabum. Dr. Lewis had sent specimens of his first case to Dr. Parkes and Mr. Busk in this country, and they had diagnosed them as belonging to the Filaridæ; and afterwards he gave to them the name of *Filaria sanguinis hominis*. These, however, were all cases of the discovery of the immature or embryonic worms. The mature worm was discovered in 1876 by Dr. Bancroft at Brisbane, and in the early part of the next year by Dr. Lewis in India. Dr. Cobbold then gave to it the name of *Filaria Bancrofti*, a name which has been rightly discarded for the prior one of Dr. Lewis. Since then the mature worm has been seen by Drs. Los Santos and Aranjo in Brazil, and by Dr. Manson in China. It is interesting to note that the mature worm is only known to exist in the lymphatics of its host, and that the immature or embryonic worm is found not only in the chyle but also in the blood.

The female worm is about 3 inches in length and about $\frac{1}{100}$th of an inch across, of an opalescent colour, thread-like, and appearing "like a delicate thread of catgut, animated and wriggling." The head is club-shaped, the mouth circular and destitute of papillæ, and the body devoid of transverse striations. Except an alimentary canal, which runs a straight and narrow course from head to tail, the body is made up almost entirely of the reproductive organs. The animal is viviparous, and is *continually* giving birth to fully-formed embryos. These embryos are of about the $\frac{1}{75}$th to $\frac{1}{90}$th of an inch in length, and about the $\frac{1}{3\frac{1}{2}00}$th or $\frac{1}{3500}$ of an inch in diameter. They are thread-like (see Fig. 1), and enclosed in a sheath, like a baby in a caul. When examined under the microscope in a drop of blood they exhibit quick eel-like movements, lashing the red

corpuscles in all directions. The number of them in the blood of a person affected with the disease of which they are the concomitants must be enormous, and Dr. Stephen Mackenzie has reason to believe that the blood of a patient who came under his care contained from thirty-six to forty millions. The eggs are about $\frac{1}{500}$th by $\frac{1}{1750}$th of an inch in length. A complete specimen of the male form has not yet been obtained, but Dr. Lewis found a broken specimen half an inch in length and $\frac{1}{180}$th of an inch across. It was thinner and firmer in texture than the female, and showed a great tendency to coil.

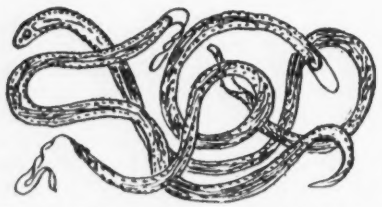

Fig. 1.—Embryos of *Filaria sanguinis hominis*.

The following measurements of a female specimen will serve to distinguish this species from any other Filarian:—

	Of an Inch.		MM.
Oral aperture to end of œsophagus ...	$\frac{1}{32}$	or	·45
Diameter of oral aperture	$\frac{1}{3000}$	„	·008
Width of neck	$\frac{1}{445}$	„	·045
„ about $\frac{1}{4}$ inch from anterior end ...	$\frac{1}{183}$	„	·162
„ where packed with ova and embryos	$\frac{1}{100}$	„	·25

Comparing its characters with those of *Trichina spiralis* and the embryo of the Guinea worm (*Filaria medinensis*), the only two human parasites with which it may be confounded, we have—

	Average Breadth.	Average Length.	Proportion of Breadth to Length	Aspect of Head.	Aspect of Tail.	Tail to Total Length
Trichina spiralis	$\frac{1}{760}$ in.	$\frac{1}{12}$ in.	1 to 28	Pointed	Blunt	
Filaria medinensis... ... ... [Embryo.]	$\frac{1}{1060}$ in.	$\frac{1}{35}$ in.	1 to 31	Rounded	Acutely pointed	1 : 3½
Filaria sanguinis hominis ... [Embryo.]	$\frac{1}{3760}$ in.	$\frac{1}{76}$ in.	1 to 46	Rounded	Acutely pointed	1 : 8

The greatest peculiarity of these parasites is their diurnal variation. If the blood of an affected person be examined between 6 a.m. and 6 p.m. none, or only a few, can be detected, while at 9 p.m. they are more abundant, and at or about midnight the blood is swarming with them. About 8 a.m. their numbers begin to appreciably decline, and at 6 a.m. no trace of them can be found. This periodicity was first observed by Dr. Manson, and has since been confirmed by Drs. Myers, Stephen Mackenzie and Lloyd Jones. What the reason of this is, has not yet been satisfactorily determined. Dr. Manson supposes that as day dawns they migrate to the blood-vessels of distant organs, like the lungs, where they cannot be easily detected; while Myers, reasoning on his observation that they become more languid and lethargic as morning approaches, thinks that they die out, and that a new swarm of embryos is produced by the females for the forthcoming night. However, the observation of Myers has not been confirmed, and it must be pointed out, as against his theory, that the parturition of the parent is not intermittent but continuous, and the enormous numbers in the blood can scarcely be considered as a single brood, even on the assumption that more than one fertile female is present in the system of the affected person. However, what determines their presence in the blood during the night-time has been clearly proved to be the resting condition of their human host. In a case which was imported from India to this country, and which came under the observation of Dr. Stephen Mackenzie, the patient changed his habits of life, and remained out of bed during the night, and slept during the day for a period of three weeks. The result was that the Filariæ were not found at all in the patient's blood during the night, but existed in immense quantities during the day-time. Dr. Manson has since confirmed this, and has also shown that if the general sleep of eight hours' duration be broken into two periods of four hours each, their numbers are sensibly diminished. Dr. Mackenzie has also shown that if the patient is awake and on the move during a thick and dark London fog, no specimens can be found in the blood.

Considering that they are chiefly embryos which are found in the human body, this periodicity is interesting in another relation. It has been shown by Dr. Manson that they have an intermediate host, and that intermediate host is a *nocturnal* species of mosquito, a species which has not been determined, but which can be recognised in the localities in which diseases from *Filaria sanguinis* occur by its dark brown colour and the absence of any markings on its abdomen, thorax, or legs.* Dr. Manson persuaded a Chinaman, who had embroyos of these Filariæ in his blood, to sleep in an outhouse which was infested with this special species of mosquito. He in the morning killed these mosquitos, which of course had been feeding upon the man, and found numbers of the embryos in their stomachs, and by a series of observations has shown that although some of them are digested yet others pierce the thorax of the mosquito and go through a series of changes in the surrounding tissues, which lead to a perfect fitness on the part of the parasite for an independent existence. This takes place in about four or five days. About the sixth or seventh day the mosquito, having laid her eggs on the surface of some pond, dies, her body becomes decomposed, and the Filariæ escape into the water, which after being drunk by some unsuspecting person they perforate the walls of his stomach and intestines and find their next resting-place in his lymphatics, just as the *Trichina spiralis* does in the muscles and the liver-fluke in the bile-ducts. The cycle now commences again; the adult female gives continuous birth to embryos in the lymphatics, and these, being no larger than the red corpuscles, make their way by the thoracic duct into the general blood stream, and so on.

It must not be supposed that persons who have Filariæ in their blood are always affected with symptoms of chyluria or elephantiasis arabum. Indeed it has been shown conclusively by Drs. Hall, Paterson, and others, that such is not the case, and that they may occur in the blood without giving rise to any external symptoms of their presence. But these two diseases are essentially due to obstructions in the flow of lymph throughout the body. Dr. Manson and several others have observed that sometimes ova instead of embryos escape from the vagina of the female, and it seems to be due to this abortive development that the diseases in question are produced; for these ova, not having the propulsive movements—the eel-like wrigglings before described—of the embryos cannot get through the narrow channels of the lymphatic glands, and so by their numbers dam back the lymph stream and stop its flow. They, in fact, act like, what is called in pathology, an embolus. As says Dr. Manson in his paper, which was read before the Pathological Society in 1880, "There will be a complete stoppage of the lymph in this particular vessel, as far back as the first anastomozing lymphatic. Along this the current will now pass, carrying with it other ova; these, in their turn, will

* The proboscis of this mosquito seems to be adapted in some inexplicable way for the purpose of extracting the embryos from the blood. The embryos become entangled in, or attracted to it, and a drop of blood taken from the proboscis of the mosquito contains a larger number than a drop of blood obtained from the person who has been bitten.

be arrested at the first gland they reach. And this process of embolism, stasis of lymph, diversion of current into anastomosis, will go on until the whole of the lymphatic glands, directly or indirectly connected with the vessel into which the parent parasite ejects her ova, are rendered impervious, provided the supply of ova is sufficient, kept up long enough, or renewed from time to time. The particular form of lymphatic disease, and the place affected, will depend on the position occupied by the parent worm, on the number of ova she ejects, on the frequency with which these miscarriages are repeated, and on the nature of the tissues involved, and individual peculiarities and accidents."

One great outcome of our knowledge of these Filariæ is the fact that these two diseases can be prevented by filtering the drinking water of the localities in which they are prevalent, but the filtering should be carried out on strict scientific principles. This is the more important since statistics reveal to us that one in every ten Chinamen is affected, and one in every twelve inhabitants of Bahia.

LUNAR AND TERRESTRIAL VOLCANOS.

By Rev. H. N. Hutchinson, B.A., F.G.S.

READERS of Knowledge will not have forgotten the Editor's interesting paper in the May number of last year on "The Great Bright Streaks which radiate from some of the larger Lunar Craters." It has been suggested to me that the question of the origin of these remarkable streaks might be discussed from the geological point of view, and that I should present some facts with regard to the lines of fracture and displacement among the stratified rocks of the Earth's crust which are known among geologists as "faults." Geological science has received valuable aid from astronomers, and possibly there are questions in Astronomy on which geologists might throw some light; at all events, it is a good thing occasionally that students of one science should endeavour to throw light on another. I only regret that the subject is not handled by one more deeply versed in lunar questions.

In my previous paper on "The Cause of Volcanic Action," I mentioned the connection between volcanos, mountain-chains, and lines of weakness in the Earth's crust, which are closely connected with lines of fracture (p. 106); and this would seem a fitting opportunity for turning our thoughts to those remarkable outbursts of volcanic action on a prodigious scale of which the Moon's numerous craters stand as silent yet speaking witnesses, and to inquire how far the cracks radiating from some of them may be compared with terrestrial cracks.

In Mr. Ranyard's paper we find a summary of the opinions put forward by different authorities on the subject of lunar streaks. "There are certainly seven such ray systems," he says, "all with craters at their centres, namely:—Tycho, Copernicus, Kepler, Byrgius, Anaxagoras, Aristarchus, and Olbers." Of these, Tycho is the most conspicuous example; its radiating streaks come out well in lunar photographs (see the illustrations, pp. 129 and 273, Vol. XIII.) The radiating streaks from Copernicus are well seen in the second photo, in the December number of 1890. Two of the longest from Tycho extend to a distance of over 1000 miles from the crater. Nichol thought, as Mr. Ranyard tell us, that they were composed of matter shot up from the interior of the Moon; and compares them to mineral veins or to "trap-dykes" (of basalt or other igneous rock), such as are known to pierce the sedimentary strata upon Earth.

Nasmyth's opinion was that the radiations "are cracks divergent from a central region of explosion, and filled up with molten matter from beneath." His experiment with a glass globe to illustrate this is described in the above paper (p. 130), also in Nasmyth and Carpenter's book on the Moon (1874, p. 134.) "Proctor seems to have favoured the trap-dyke theory. Neison, after carefully setting out the observed facts, refrains from advancing any theory." Young hesitates between this theory and the idea that they may be mere surface markings. Mr. Ranyard himself thinks "that they correspond to a series of radiating cracks, or faults, from which comparatively warm air issues charged with aqueous vapour, which is deposited as hoar-frost on either side of the vent."

Thus there seems to be a consensus of opinion that, in some way or other, the radiating streaks are due to cracks, and we can only conceive of such fractures as being due to a disruptive action, originated by the reaction of the interior of the Moon upon its outer crust. Taking so much for granted, we may pass on to the question of the nature of the disruptive force. Was it due—as Messrs. Nasmyth and Carpenter say—to the expansion of molten rocky matter below the Moon's surface on nearing the point of solidification? or was it originated by the cooling and consequent contraction of the body of the Moon which would leave the outer crust here and there unsupported, and hence this crust in settling down and endeavouring to adapt itself to a smaller surface below would undergo tangential strains and thrusts, which, it is easy to conceive, might result in a certain amount of fracturing? A simple illustration of this is afforded by the wrinkling of the skin of an apple as it dries. The soft pericarp below shrinks as it loses water, and so the skin has to settle down and accommodate itself to a smaller surface, and in doing so it must inevitably be wrinkled, or thrown into folds. This is a view which might perhaps commend itself to a geologist, for it is on a similar theory that geologists explain the great foldings which have produced terrestrial mountain chains, which latter are clearly connected with lines of weakness or fracture such as they suppose allowed rocky matter from below (charged with steam) to well up to the surface and so give rise to volcanic action. Volcanos, as we pointed out in our last paper, have a striking connection with mountain chains. On this view the folding, contortion and fracturing of strata, so conspicuous in mountains, is a secondary result of the secular refrigeration of our planet. Nothing short of this seems, at present, equal to the Titanic work of upheaval. At the same time the theory is not proved, and some authorities refuse to accept it.

Let us now turn to the Earth and see what Geology tells us about terrestrial cracks. These are of two kinds; first, there are the "faults," to which we have already referred; secondly, the "trap-dykes," which are very numerous in Scotland and northern England.

It may easily be conceived that the force which was sufficient to raise vast masses of solid rock of immense thickness from the bottom of the sea, where they were deposited, high into the air in order to form dry land, and, moreover, to bend them into great folds and contortions of all sizes, might also be sufficient to crack and break them through. Accordingly we find in the stratified series very frequent instances of cracks running through great thicknesses of rock, and obviously caused by disturbing force; sometimes they are mere fissures, but more frequently there is not only a severance but a displacement of the rocks that have been severed. Strata

XUM

once continuous are left at very different levels on opposite sides of the fissure. Hence the term "fault." Some of the "faults" known to geologists are not only of great horizontal length as traced along the surface, but of very considerable depth, and have produced enormous displacements. Thus the great Pennine "fault" of the north of England is known to be at least 55 miles long, and has a "throw" of 6-7000 feet, *i.e.*, the rocks on either side have been displaced to that extent. It was probably formed at some time during the upheaval of the Pennine range of hills, which runs north and south as the "fault" also does. The Tyndale "fault" has a throw of nearly 8000 feet, and it runs eastwards for about 50 miles. Fractures not unfrequently occur along the axes of great folds, such as we find in mountain chains, the strata having snapped under the great tension to which they were subjected during upheaval. Thus we find "faults" running parallel with some of the great mountain chains of the world; the Alps and Himalayas are cases in point.

This connection between great terrestrial cracks and important mountain ranges is only what might have been expected. The Unita Mountains of Wyoming and Utah consist of one broad flattened fold, with a displacement, in places where the uplift has been greatest, of 20,000 feet! If the lunar streaks under consideration are due to "faults," it is difficult to understand how the level on each side should be so little disturbed. As a general rule, the brightness of the lunar surface corresponds to the altitude of the ground. Mr. Ranyard says the rays do not correspond to lofty ridges, or even to ridges a few hundred feet in altitude, for no ridges casting shadows as the sun rises and sets can be detected as coincident with the streaks. It seems generally admitted that they do not correspond to lava-streams, for the rays run across mountains and plains, and even through the rings and cavities of old craters.

Believing the trap-dyke theory to be the most plausible explanation, we would like to ask whether, in spite of no shadows having yet been detected, the rays may not be due after all to *slight ridges* of igneous rock welling out in a viscous state from long cracks, and so catching a little more light than the surrounding parts of the lunar surface. Such ridges might be no more than 100 or 200 feet in height, and if their sides slope gradually it might be impossible to detect their shadows. We may also suppose they consist of some light-coloured trap-rock, such as felstone, and to be "weathered" by the lunar atmosphere, thus presenting a somewhat whitened surface. It is quite possible that the lunar trap-rocks may be of a highly siliceous nature, like "volcanic glass," also that they may have been considerably weathered and whitened by the action of great quantities of steam, now absorbed by the Moon, emitted in the last phases of lunar volcanic action. We know that steam can act chemically on glass, and turn it white. The lunar photograph in Mr. Ranyard's paper shows that the streaks are not nearly so bright as some mountains and craters, but this would easily be accounted for by the very great difference in height. Our idea is that the lunar mountain ranges are composed of volcanic rocks thrown up in some way from lines of fissure, and that the streaks are, as it were, attempts at lunar mountain ranges, which failed because for some reason the lava was not forced up in sufficient quantity. We rebel, for several reasons, against the idea of the lunar mountains being covered with snow. For instance, there is a great difference in the whiteness of different lunar mountains, which would be impossible if snow were the cause of the whiteness. But if they are composed of different kinds of trap-rock, it is extremely likely that they would weather differently, so that some might be whiter than others. Those, like basalt, of a more basic character (*i.e.* with more lime and magnesia), would be of a darker colour, while others, like felstone (which is acidic and contains much free silica), would be of a lighter hue.

In looking over the beautiful pictures in Messrs. Nasmyth and Carpenter's book, we notice another point which seems to favour this idea—namely, that short lines of mountains are so often seen in connection with lunar craters, sometimes roughly radiating from them, sometimes all more or less in one direction. We observe this especially in the pictures of Gassendi (the frontispiece), Copernicus, Archimedes, Aristotle and Eudoxus, Trisnecker, Plato, Mercator and Campanus, and also very plainly in the photo of Aristarchus and Herodotus. Again, the occurrence of craters in lines, in some cases, is another important fact tending to confirm this idea. (It will be remembered that terrestrial volcanos run very markedly in lines.) It may be well here to quote the authors above referred to. They say (p. 98): "We have upon the Moon evidence of volcanic eruptions being the final result of most extensive dislocations of surface, such as could only be produced by some widely diffused uplifting force. We allude to the frequent occurrence of chains and craters lying in a nearly straight line, and of craters situated at the converging point of visible lines of surface disturbance. Our map will exhibit many examples of both cases. An examination of the upper portion (the southern hemisphere of the Moon) will reveal abundant instances of the linear arrangement. Three, four, five, or even more crateral circles will be found to lie with their centres upon the same great-circle track; proving almost undoubtedly a connection between them, as far as the original disturbing force which produced them is concerned. Again, in the craters Tycho, Copernicus, Kepler and Proclus, we see instances of the situation of a volcanic outburst at an obvious focus of disturbance."

On this theory, the dark linear markings on the Moon, known as "hills" or "clefts," are probably cracks up which, for some reason, the molten matter only welled-up to some point below the surface. Perhaps they formed later than other terrestrial features, after the volcanic fires had died out, and when the linear surface was losing its old heat rapidly and therefore cracking as it contracted on cooling.

It must be confessed that there is little to be said in favour of the view that the lunar streaks have been produced in a similar way to terrestrial "faults," for several reasons: First—the mountains of the Moon, as far as we can see, are different to terrestrial mountains, and seem to be entirely volcanic, whereas our mountains are mostly due to the upheaving and folding of sedimentary strata; their present outlines being the result of long-continued atmospheric denudation. Secondly—it seems to me impossible, in the present state of our knowledge, to say whether stratified rocks are present on the lunar surface. If at one time there were seas, and an atmosphere at all like ours, "denudation" must certainly have taken place, and that would involve the accumulation of marine sedimentary deposits. Many believe that there is evidence of stratification and even of tilted strata in the lunar Apennines; but if this is the case, I should prefer to consider such strata as purely volcanic, viz., lava and ashes. Thirdly—terrestrial "faults" are very sharp lines of division, like the cracks which form in a sheet of ice after continued skating, so that we could not expect to see them.

One word in conclusion about "trap-dykes." These are veins of eruptive rock (basalt, &c.) filling up vertical

or highly inclined fissures, and are so named on account of their resemblance to walls (*Scottice*, dykes). When the surrounding rock has decayed, the dykes may be seen projecting above ground exactly like walls. Sometimes the eruptive rock has followed the course of a "fault"; but in Scotland, at least, the vast majority of dykes rise along ordinary fissures which, having caused no displacement, cannot be considered as "faults." On the contrary, the dykes may be traced undeflected across some of the largest "faults." Dykes differ from veins in the greater parallelism of their sides, their verticality, and greater general regularity. Usually a dyke cannot be traced far, but the well-known Cleveland Dyke, in the north of England, runs for at least 60 miles, cutting through various "formations" till it reaches the Yorkshire coast, 200 miles or more from the sheets of Miocene trap-rock with which it is probably connected. The south-western half of Scotland, and the northern parts of England are ribbed across with thousands of dykes which seem to be connected with the volcanic chain of the inner Hebrides (of Tertiary age). The fissures through which such dykes forced their way were not made by the molten matter itself, but more probably were the result of violent explosions and earthquakes proceeding from a region of volcanic action.

I must now conclude this paper, leaving the reader to judge if I am warranted in applying the trap-dyke theory to the lunar streaks. It certainly harmonizes lunar and terrestrial phenomena, and suggests a close connection between radiating streaks, chains of lunar volcanos, mountain ranges, and ridges or lines of hills near the volcanos.

REMARKS BY A. C. RANYARD.

If the reader will turn to the photographs of the Moon, published in KNOWLEDGE for May, 1890, and October, 1889, he will see that the rays or streaks have not sharply defined edges as they presumably would have if they were trap-dykes. The rays vary in breadth, many being from twenty to thirty miles broad, with very soft nebulous edges. The whiteness of the rays in some cases may be seen to degrade gradually from a narrow, sinuous, bright band which runs along their centres—see, for example, the two rays from Tycho that run across the Mare Nubium, shown in the plate published in the May number for 1890. The rays seem in no way to interfere with the forms of the craters and irregularities of the lunar surface, as we should expect to find them interfering if they corresponded to a wall of injected rock either harder or softer than the surrounding material. A good instance of a broad ray passing over craters and rough ground without affecting the forms of the craters and mountains is shown in photograph No. 1, plate No. 1, in the October number for 1889, where a strikingly bright ray radiating from Tycho passes across the rough ground to the south of the Mare Nectaris and then across the plain and onward.

Lava streams and volcanic regions on the earth are generally dark as compared with the surrounding rocks, but the light-reflecting character of these rays cannot be accounted for unless they are capable of reflecting more light than light sandstone, or even than chalk. For the light-reflecting power of the Moon, taken as a whole, about corresponds to that of light sandstone. See the often quoted observation of Sir John Herschel, who compared the light of the nearly full Moon with that reflected from Table Mountain at the Cape. Everyone is familiar with the whitish appearance of the Moon as seen in the day-time. It appears like a small whitish cloud.

There are many large dark areas upon the Moon, consequently the brighter parts must be relatively white as compared with light sandstone. It is true that the summits of lunar mountains and craters differ greatly as to their whiteness, but few terrestrial mountains are wholly covered with snow, and, as seen from a distance, their whiteness would depend upon the amount of rock surface and shadow intermixed with the snow. The Moon, as a whole, reflects a little less than a quarter of the light reflected by fresh fallen snow. My argument is that the brighter patches and rays are so bright as compared with the rest of the Moon's surface that their whiteness cannot differ greatly from the whiteness of snow.

THE CHEMISTRY OF THE DAIRY.

By VAUGHAN CORNISH, B.Sc., F.C.S.

IT is often felt as a disappointment by persons who have been at some pains to acquire a knowledge of the principles of chemistry, that the chemistry of the breakfast table remains still beyond their ken. Common salt presents no difficulty, but what are mustard and pepper, sugar, milk and butter? Many a chemist has had his breakfast spoilt by being called upon to explain the composition of these things when he would rather be availing himself of their nutritive properties. The "Professor at the Breakfast Table" may sometimes indulge the didactic vein, but only in a moment of unusual rashness will the professor attempt an untechnical exposition of the constitution of organic bodies. The reason is not far to seek. The number of organic substances is very large, being reckoned, indeed, by thousands. The great majority of these consist of carbon and hydrogen, of carbon, hydrogen, and oxygen, or of these three elements together with nitrogen. A mere statement of the elements contained in the substance gives practically no information as to its nature. Each chemical substance is made up of a number of small parts, the *molecules*. The properties of the substance are determined principally by the properties of the molecules. The molecules of organic substances are differentiated from one another, chiefly by the number of atoms in the molecule, and by the mode of arrangement of these atoms, rather than by the nature of the atoms themselves. The connection between the arrangement of the atoms and the properties of a substance is subtle and intricate, and the experiments required for the discovery of the mode of arrangement of the atoms are complicated and difficult to follow. There is no royal road to this branch of knowledge; a general grasp of organic chemistry can only be gained through the laborious study of detail. It is possible, nevertheless, to impart a certain amount of information concerning the chemistry of foods without demanding this knowledge of details. It is true that the acquaintance which is thus gained is far from being satisfying to the enquiring mind, but it is nevertheless thus far satisfactory that it has a definite practical value.

The present article, within the limits we have indicated, deals with the chemistry of milk and of the food-stuffs prepared from it. Milk may be described as an emulsion, its opacity being due to the dissemination throughout its bulk of a great number of small globules of fat. This fat swims in a watery fluid, not pure water but an aqueous solution of caseine, milk sugar, and a small amount of inorganic matter consisting chiefly of common salt and phosphate of lime. In the study of milk, cream, butter

and cheese we are principally concerned with the various proportions in which these articles contain the three constituents, fat, caseine, and milk sugar. Our mode of treatment of the subject precludes us from attempting a detailed explanation of the chemical nature of each of these ingredients; we merely draw attention to the fact that fats and sugars possess distinct and valuable nutritive properties (chiefly as fattening and warming diet), whilst caseine, which is the only one of the three containing the element nitrogen (which constitutes about 15 per cent. of the caseine) helps to form tissue, its presence in cheese giving that article its value as a substitute for meat diet. The composition of the milk of cows only varies within somewhat narrow limits. Change of diet affects rather the quantity than the composition of the secretion, milk in this respect resembling the blood rather than certain other animal fluids. It is true that the diet affects the flavour (as in the case of a turnip flavour from swedes if eaten shortly before milking time), but this is apparently due to the presence of a very small quantity of a strongly-tasting material, the percentage composition of the milk being practically unaffected. Below are given representative analyses of—

(1) Ordinary country milk.

(2) Of town milk from stall-fed cows, which is generally somewhat richer in fat.

	Country Milk.	Town (stall-fed) Milk.
Water	87·55 %	... 85·94 %
Fat	3·09	... 4·00
Caseine	4·01	... 5·01
Milk sugar ...	4·63	... 4·31
Ash	·72	... ·74
	100·00	100·00

We have said that the composition of cows' milk varies, though only within somewhat narrow limits. Rich milk contains more fat, poor milk more water; the dissolved substances (caseine, milk sugar, and the inorganic substances), which are often referred to as the *milk solids not fat* constitute a nearly constant quantity. The determination of the milk solids not fat affords a means of ascertaining if the milk has been *sophisticated*, that is to say, has undergone artificial alteration of its composition. Thus a milk with a somewhat high percentage of water would pass as a naturally poor milk if the solids not fat were in the usual proportion to the total weight of the milk, but if the amount of these solids is too low the conclusion can be drawn that the milk has been watered. Skimming the cream or fat from the surface of the milk would make the percentage of solids not fat too high. It is true that it would be possible to combine the two processes of skimming and watering so as to leave unaltered the percentage of solids not fat, but in this case the ratio of water to fat would be greater than is admitted by the known range of variation in the composition of the natural milk. This device of combined skimming and watering is said to be sometimes resorted to in order to baffle the inspector and his lactometer. The specific gravity of milk is about 1·03 (water being taken as unity). The fat is lighter than water, therefore skimming raises the specific gravity. Ordinary well water is lighter than milk (owing to the presence of the solids in solution in the watery fluid of the milk), hence watering lowers the specific gravity. Though the lactometer—which indicates the density by the depth to which it sinks—is devised to detect either mode of sophistication, yet a skilful combination of the two will baffle the instrument. As we have shown, however, analysis is capable by an indirect method of detecting this mode of sophistication. It is, nevertheless, unfortunate that there is no *direct* test known by which added water can be discriminated from that of the natural milk. It is probable that the adulteration of milk with impure water has sometimes resulted in the propagation of disease.

When milk is left to stand, the globules of fat, being lighter than the liquid in which they float, gradually rise to the surface, a layer of cream being formed. The richness of the cream thus produced varies greatly, the percentage of fat being sometimes less than 20, sometimes more than 40. The watery fluid of the cream has nearly the same composition as that of ordinary milk, and by the determination of the proportion of water to milk solids not fat the analyst is enabled to judge if the article has been treated by watering.

In cream the globules of fat are more closely aggregated than in milk, but when the cream is subjected to prolonged agitation, as is done in the churn, the globules actually cohere, and a solid mass separates from the butter-milk, which consists principally of water, caseine, and milk-sugar. The salt, which is added as a preservative, and for flavouring purposes, passes largely into the butter-milk, that which remains in the butter being kept in solution by the water present. Good butter usually contains about 14 per cent. of water, 2 per cent. of salt, and a very small quantity of caseine, the remainder, or more than 80 per cent., being fat. Its value as a food depends on the proportion of fat, but the importance of freeing the butter as much as possible from water arises also from the circumstance that water in an undue proportion not only lessens the nutritive value but prevents the butter from keeping. Although rich butter consists principally of milk fat, the fat by itself would prove unpalatable.

Fats other than milk fat, chiefly the fat of meat, are now largely employed for the preparation of a substitute for butter. They possess some of the valuable qualities of milk fat, but are inferior in flavour, and less easily digested. Margarine is sometimes made wholly from these fats, whilst the more expensive kinds contain milk fat, sometimes in quantity equal to that of the foreign fats. Formerly the detection of foreign fats in butter could not be made with certainty, but as the practice of adulterating butter in this way became more general, new methods of analysis were elaborated, and now the detection of foreign fats can be made readily and with certainty. Any material containing an admixture of foreign fats is, legally, margarine, and its exposure for sale without the well-known label is punishable by fine. The examination of "reputed butter" now forms a considerable part of the public analyst's work. A usual method of procedure is to determine, by a quick process, the specific gravity of the melted fat. If the specific gravity is below that of butter fat, a chemical analysis is made. The principal tests are those depending on the fact that milk fat yields about ten times as much butyric acid as other fats, and that the ordinary margarine fats yield a larger proportion of the so-called *unsaturated* acids. These have the power of combining with iodine, and their presence may be detected by the *iodine-absorption* test, which consists in determining the change of strength which takes place in a standard iodine solution when left in contact with the material.

In the process of butter-making, as we have seen, almost all the caseine and the milk sugar are left in the butter-milk. In Germany, milk sugar is extracted from butter-milk for the purpose of adding it to ordinary cows' milk intended as food for infants. In this way a milk is obtained which approximates closely to the natural food of children, which contains a larger proportion of sugar than the milk of the dairy.

In the manufacture of cheese the nitrogenous material of milk (caseine) is thrown out of solution in the solid form by the action of *rennet* (an infusion from the stomach of the calf), whilst the greater part of the milk sugar remains in solution in the whey. Cheese contains also inorganic matter and a variable proportion of fat. A large proportion of fat imparts richness to cheese, the richest cheeses, such as Stilton, being made from milk with added cream. There are also cheeses made from ordinary milk, or "whole milk" cheeses, and cheaper kinds made from skim milk. In these different varieties the proportion of fat varies from 20 to more than 40 per cent., the proportions of caseine and of water having about the same range. It sometimes happens that margarine fats are used in making cheese, as an economical method of imparting "richness." The detection of the fraud may be made by separating the fat and subjecting it to the same tests as in the analysis of margarine.

ON THE FERTILIZATION OF TWO COMMON BRITISH ORCHIDS.

By J. Pentland Smith, M.A., B.Sc., &c., Lecturer on Botany, Horticultural College, Swanley.

FOR some years Orchids have been in high favour with florists and that section of the flower-loving public who can indulge in the luxury of a hot-house. Most of the quaint and beautiful specimens one sees have their home in the tropics, and are epiphytes (that is, they obtain the whole of their food from the air). We will content ourselves with the examination of two plebeian members of the family that are to be found in plenty in England, and are of terrestrial growth. They are quite as interesting as their exotic brethren. The first of these, the early purple Orchis (*Orchis mascula*), a month ago was flowering in our woods. The first thing that strikes the casual observer on examining these Orchid flowers is the curious shapes they assume, a circumstance that has led to the application to them of such names as Butterfly Orchid, Frog Orchid, and Bee Orchid, these names indicating their supposed resemblances to living creatures. The appearance of the early purple Orchis is no less striking. This name has been applied to it on account of the reddish-purple flowers that make their first appearance during the month of April. It continues flowering until July, its flowers are grouped in spikes, and are occasionally almost white. They arise from the axil of a coloured bract.

In plants with net-veined foliage leaves, the outer covering of the flower—the *calyx*—is composed, as a rule, of green-coloured modified leaves (*sepals*). But the Orchid ranks amongst the Monocotyledons—plants with parallel veined foliage leaves, and coloured sepals—which are thus often indistinguishable from the inner whorl of enveloping organs (the *petals*). Fixing our attention on a single flower, and holding the spike so as to bring the flower next us and the stalk or *axis* from which it springs away from us, we notice that one of the three sepals lies next the axis, and is consequently further away from the body of the spectator than the other parts of the flower, and is superior in position to these; it is thus said to be posterior or superior, while the other two are termed the lateral sepals. Alternating in position with these organs are three petals. The two lateral ones are of small size; the third, or odd one, is anterior or inferior in position, and is abnormally developed into a broad, expanded, purple-spotted lip, or three lobes. The middle lobe is longer than the others and is notched at the tip. This petal is termed the *labellum* (Fig. I. 1). An opening near its point

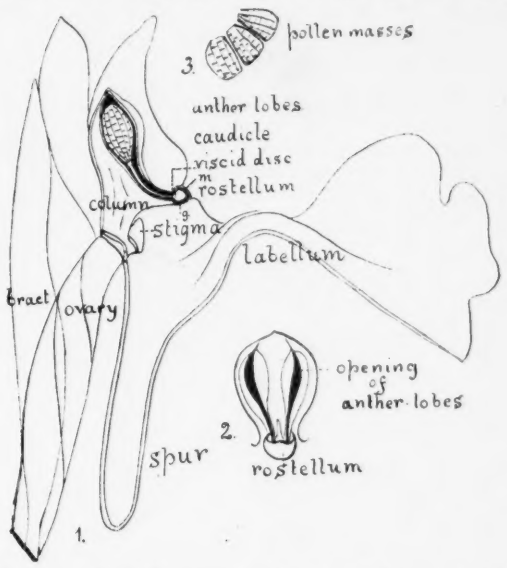

Fig. I.—1. Semi-diagrammatic view of the flower of *Orchis maculata*, magnified (which agrees practically in structure and in method of fertilization with *Orchis mascula*). The ovary is made to shine through the bract; the labellum is cut through the middle, and the left anther-lobe is also seen in section. The left petal is removed.

2. Front view of stamen and rostellum.

3. Group of pollen-masses.

of origin leads into the canal of a stout pouch or spur, with which it is furnished. Situated opposite the posterior sepal there is a shield-shaped body, at whose base is a small bulbous swelling, the *rostellum* (Fig. I., 1, 2). The latter more or less obstructs the entrance to the pouch of the labellum which it overhangs. The sides of the shield are swollen; the swollen portions (Fig. I., 2) narrow as they approach the rostellum, and each one is slit from top to bottom. A closer examination of these will amply repay us for the time so spent. First, then, we will take a fully-expanded flower, and insert the end of a well-sharpened lead-pencil into the spur of the anterior petal. If withdrawn immediately, two small Indian club-shaped bodies (Fig. I., 1) will probably be found adhering to it. We say "probably," because these bodies may have been removed already. They are simply masses of pollen (Fig. I., 3) held together by elastic threads. The union of the threads forms the handle of the club, and is called the *caudicle* or little stalk; the caudicle rests on a small plate of tissue termed the *disc*. The whole structure is called a *pollinium*. Further examination of the swellings of the shield shows that their cavities are now empty; the pollinia formerly occupied them.

In an ordinary flower, the pollen grains are contained in two lobes at the summit of the stamens, called the anther-lobes. When these open the pollen grains fall out as a fine powder, as they are more or less free from one another, but in Orchids the contents of each anther are shed *en masse* in the shape of the pollinia described above. Each swelling of the shield is thus an anther-lobe, and the whole shield is a *stamen*. The tissue between the lobes is the connective, the upper portion of the stalk or filament of the stamen. The great separation of the lobes from one another is not unique. It is frequent in other kinds

of flowers—*e.g.*, *Berberis vulgaris*, the Barberry; *Salvia*, the Sage.

The little discs to which the caudicles are attached are sticky on the under surface. The viscid material enables them to adhere to the proboscis or head of any insect with which they come in contact. The filament of the stamen has not yet been seen by us—in fact, search for it would be in vain, as it has united with the pistillate or female portion of the flower to form the *column*. It is evident, then, that only one stamen is present in the flower. A vertical section through the rostellum of another flower which has not been robbed of its pollinia reveals the source of the viscid material of the disc, and also of the discs themselves, for the rostellum is a thin membrane (Fig. I., 1 *m*.) whose interior is lined with a granular fluid (Fig. I., 1 *g*.) that surrounds two balls of viscid matter, only one of which is seen in Fig. I., 1. Each ball is attached to a circular piece of thin membrane, thinner than the rest of the membrane of the rostellum, but confluent with it. As is evident from the figure, the discs are developed towards the back of the flower and the pollinium assumes a curved position in its case.

Situated beneath the rostellum are two protruding sticky patches almost united to one another. They are the stigmatic surfaces (Fig. I., 1). The flower is supported on a thick twisted stalk. Fig. III., 4, is a section of the similar stalk of Habenaria, the Orchid we are next to consider. It is lined with three longitudinal rows of ovules, and so it is the ovary of the flower. It is important to note that it is twisted. The style (that portion of the pistil that is generally elongated and bears the stigma on its summit) is here very short, forming part of the column, as already noted.

A wonderful mechanism comes into play in connection with the removal of the viscid discs. Whenever an insect touches the rostellum, the delicate membrane ruptures before and behind, so as to leave the discs free. At the same instant it springs downwards and exposes the balls of sticky matter, which then come in contact with the animal's body. The manner in which fertilization is accomplished is as follows:—An insect alights on the labellum, and in endeavouring to push its proboscis into the nectary to obtain honey, it infallibly knocks its head against the irritable rostellum. The mechanism already described then comes into action, and the insect leaves the flower with one or both pollinia firmly affixed to its head. It may repeat the process on other flowers of the same spike, so that when it flies off from it many pollinia may be attached to its body. Darwin, to whom we are chiefly indebted for our knowledge of the processes of Orchid pollination, says that he found ten to sixteen pollinia attached to the bodies of live bees that had been visiting an ally, *Orchis morio*.

Bees only spend three or four seconds on each flower; hence it is evident that the sticky material of the discs cannot take long to harden, and this is so. It is also quite apparent that unless the pollinia changed their position on the insect's head that insertion of the proboscis into the nectary of another flower would simply lodge the pollinia relatively in their old position. To prevent this, a marvellous contrivance is exhibited. The small viscid disc has such power of contraction that it causes the pollinium to move in a forward direction through an angle of 90°, thus bringing it into a position that ensures its impinging on the stigma of another flower visited by the bee. It must be understood that the discs are firmly fastened to the insect's head. Were it not so, in moving, they might assume a lateral direction, which would prevent them performing the act of pollination. The cement sets hard, according to Müller, in from three to five seconds when exposed to the air, and this is the time occupied by the bee in visiting a single flower. About forty seconds, as a rule, elapse before the pollinia bend forward. A bee, as a rule, spends twenty-five seconds on a single spike; thus, fertilization with pollen from the same inflorescence is obviated. The time occupied in flying to another spike gives the pollinia the opportunity of assuming the position requisite for the performance of the act of pollination.

It frequently happens that only one pollinium is removed at a time; hence, unless some special contrivance were provided, the other pollinium would be useless owing to the exposure of its cement to the air by the lowering of the membrane of the rostellum. This is obviated by the power inherent in this membrane of springing back to its place immediately a pollinium has been removed.

Müller records an interesting study he made of the cross-fertilization of this Orchid. "On May 6th, 1869, I and my son Hermann at length succeeded in observing humble-bees fertilizing the flowers of Orchis upon Stromberg Hill. As we lay upon the turf, which was overgrown with *Orchis mascula*, we saw a humble-bee (apparently *Bombus terrestris*) alight, close beside us, on the base of a spike of that plant. It thrust its head into a flower, and drew it out, after about four seconds, with the pollinia attached to it. It repeated the same operation on two more flowers. After withdrawing its head from the third, it paused, and tried without success to free itself from the pollinia, which were cemented firmly to the front of the head. Climbling a little further up the spike, it thrust its head into a fourth flower. . . . Of ninety-seven humble-bees which we caught on that day on Stromberg Hill, thirty-two bore pollen-masses of Orchids."

Although one repeatedly examines the nectaries of *Orchis mascula*, one always finds them destitute of nectar. This was a puzzling circumstance to Darwin. He could not account for the continued visits of insects to these flowers unless by the fact that they themselves benefited by it. In fact, so strongly convinced was Sprengel that no nectar was produced under any circumstance, that he called them sham-nectaries. Darwin, however, could not believe that insects would allow themselves to be so systematically duped. But not a drop of nectar was revealed even by microscopic examination. At last he found a clue. The spur of the labellum has a comparatively thick wall, and its inner membrane is delicate; moreover, the juicy nature of its contents is very evident. In Habenaria there is a copious supply of nectar, and the wall of the spur is thin. Darwin observed that bees which visited the flowers of *Orchis morio* "remained for some time with their proboscides inserted into the dry nectaries, and (he) distinctly saw this organ in constant movement. (He) observed the same fact with Empis in the case of *Orchis maculata*, and on afterwards opening several of the nectaries (he) occasionally detected minute brown specks, due as (he) believed to the punctures made some time before by these flies." This then is the solution of the problem—the insect bites with its mandibles the fine inner membrane of the wall of the spur, and sucks out with its proboscis the fluid contained therein.

It will be remembered that the pollinia cannot be affixed to the head of the insect visitor unless the cement of the disc has hardened. This requires about three or four seconds, the time spent by the insect in piercing the wall of the nectary. We see then how beautifully, even to the minutest detail, this flower has been modified in order to ensure its cross-fertilization.

For its intrinsic interest and as affording a contrast to the preceding, we will examine the structure and mode

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CATTLEYA MOSSIÆ.

This epiphytic Orchid is a native of La Guayra, on the coast of Venezuela. It derives its nourishment wholly from the air, clinging to other objects merely for support. The flowers are very large and fragrant. The photograph is on half the scale of Nature.

Direct Photo Eng. Co., Limited, 9, Barnsbury Park, N.

XUM

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of fertilization of *Habenaria chlorantha*, the Butterfly Orchis. It is quite a common form, flowering during June and July in meadows and on heaths. It is noted for its fragrance and for its pure white, but generally greenish-yellow flower (χλωρος, green, and ανθος, a flower). The spur is very long, at least twice the length of the ovary. The labellum is strap-shaped; hence the name *Habenaria* (*habena*, a thong) according to some authors, although Hooker says the etymology is doubtful.

The connective is largely developed, so that the two anther-lobes are very much separated, especially at the base (Fig. II.). The discs of the pollinia are thus far apart. The viscid matter is not enclosed in a pouch as in *Orchis mascula*, but is free on the under surface of the discs which face one another (Fig. II. *d*.). These occupy a position anterior to the two united stigmas situated beneath (Fig. II.). Another curious arrangement is seen here.

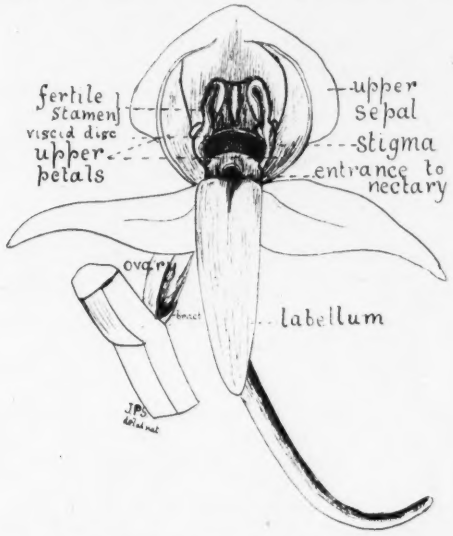

FIG. II.—Front view of flower of *Habenaria chlorantha* (Butterfly Orchis).

Instead of the caudicle being attached at once to the disc, it is hinged to a small process that arises perpendicularly from the upper surface of that organ, and is called the *pedicel*. The pollinia lie far back in their cells, so that the caudicles are slightly bent. In their natural position each caudicle is at right angles to the pedicel, and consequently parallel to the viscid disc (Fig. III., 1, 2). The nectary is generally two-thirds full of nectar, and so is visited frequently by insects. The fragrance of the flowers, and their light colouration, admirably fit them for the visits of insects that fly by night. These are in this case moths. It frequently happens that, on account of the distance between the discs, only one pollinium is removed at a time. They are often found adhering to the eye of the insect. The viscid matter does not set hard immediately, but is of such a nature as to fix the pollinia firmly to the head of the intruder without setting.

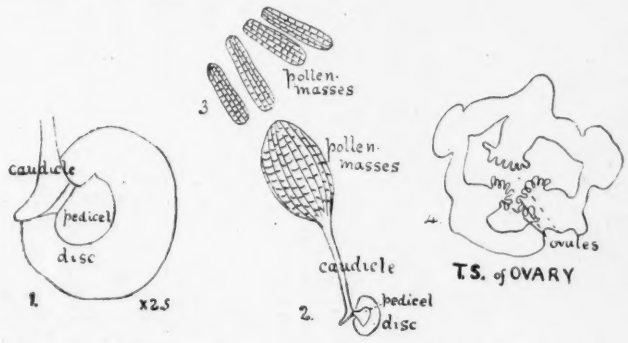

FIG. III.—*Habenaria chlorantha*. The parts are as noted in the figures.

It is clear that unless some movement of the pollinia takes place after their fixation to the insect's head, that fertilization will not be effected. The pedicel performs the needful act. It contracts along one side, and at the same time moves through an angle of nearly 90°, dragging the pollinia inwards and downwards, and in the exact position to strike against the stigma when next an insect visits a flower of the same species.

As the viscid material does not require to be set hard, but performs its office immediately, there is no puncturing of a nectary required to detain an insect; instead, there is a free supply of nectar.

The structure of the Orchid flower is quite anomalous, but it can be reduced to the normal type, though it required the genius of Darwin to work it out. The parts of a flower are generally developed in whorls, and the members of one whorl alternate, as a rule, with those of the adjacent whorls. Exceptions to this rule can generally be accounted for by displacements that have occurred during the development of the floral parts. The significance of the organs of the Orchid are more difficult to determine. Darwin accomplished the task by counting the groups of bundles of spiral vessels that proceeded from the ovary. These are in part the constituents of the *veins* of a leaf. Their presence would denote the presence of a leaf or modified leaf at an early stage in the development of the flower, as they are generally the first differentiation exhibited in the tissues of a growing mass of cells of a higher plant.

Fig. IV. is the result of his labours in this direction. In *Orchis mascula* and *Habenaria chlorantha*, and in all Orchids, with the exception of the *Cypripediums*, there is only one fertile stamen—the posterior one of the outer whorl. The other two belonging to this whorl have become united to the anterior petal to form the labellum. Of the three stamens of the inner whorl none are represented in the Orchids whose fertilization we have described. In *Cypripedium* the two lateral stamens of the inner whorl are the fertile ones, while the posterior stamen of the outer whorl forms a large head which projects above them. When the third stamen of the inner whorl is present, it unites with the anterior portion of the column, and so acts as a support.

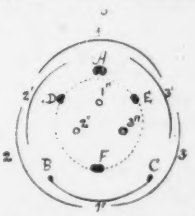

FIG. IV. — Ground plan of typical Orchid flower. 1, 2, 3, sepals, 1 is the posterior sepal; 1′, 2′, 3′, petals, 1′ is the anterior petal; A, B, C, outer whorl of stamens. B and C are united to the anterior petal and so help to form the labellum; A is the fertile stamen in all Orchids with the exception of *Cypripedium*; D, E, F, stamens of inner whorl, none of which are present in *Orchis mascula* and *Habenaria chlorantha*—in *Cypripedium* D and E are the fertile stamens; 1″, 2″, 3″, stigmas; 1″ is modified to form the rostellum.

There are three stigmas corresponding to the three groups of ovules in the ovary. But only two of the stigmas act as such; the posterior one is modified to form the rostellum, whose viscid matter has been formed in the cells of which it was originally composed, and which have afterwards broken down.

Another point of interest remains to be noted in regard to the position of the floral parts. The ovary is twisted in such a way as to cause the truly anterior portions of the flower to hold a posterior position and *vice versâ*, but in the foregoing description, and in Fig. IV., no account has been taken of this. The labellum, for instance, has been spoken of as the anterior petal and two anterior stamens of the outer whorl united, whereas the adjective posterior would be the correct one to use.

SWIMMING ANIMALS.

By R. Lydekker, B.A., Cantab.

In our last article we discussed the various structural modifications by means of which the members of different groups of animals are enabled to fly, or, in other words, to swim in the aërial ocean. From the observations recorded there, it is evident that all the creatures adapted for this peculiar mode of life have been specially modified for that purpose; flight thus always being a power which has been specially acquired, and not one which was an original attribute of any group of animals.

It is our purpose in the present essay to notice in a somewhat similar manner the various adaptations of the structure of certain animals whereby they are enabled to swim in the denser medium of water. And here we shall find that while there is conclusive evidence to show that in many instances this power is an acquired one, yet there are others which lead to the belief that in certain groups it is a primitive function. Some clue as to the groups in which this power of swimming is an acquired one, and those in which it is a primitive one, is afforded by the different modes in which aquatic animals breathe. Thus in fishes the air necessary to oxygenate the blood is obtained from that dissolved in the water itself by its constant passage over those peculiar comb-like organs, highly charged with blood, known as gills; such animals having, therefore, no occasion to come to the surface of the water to breathe. In other animals, however, such as Whales and Grampus (Fig. 1), atmospheric air is breathed directly by means of lungs, necessitating visits at longer or shorter intervals to the surface, and it is in such instances that we may safely infer that the adaptation to an aquatic life has been gradually developed from ancestors whose normal habits were terrestrial, since otherwise the gills would never have been lost. That animals whose original mode of life was a purely aquatic one have tended in some cases to assume a terrestrial existence is proved by the case of the Common Frog, which commences life as a gill-breathing, swimming creature, which is to all intents and purposes a fish, and ends by being an air-breathing reptile, as much at home on land as in the water, although retaining the power of swimming. On the other hand, the Seals and Otters show us how an originally terrestrial type of animal has become adapted to pass a large part of its time in the water, which has become its natural element.

The term "Swimming Animals" is, of course, a very wide one, since a considerable proportion of animals whose normal habits are terrestrial can, on occasion, swim with more or less facility. Our application of the term will, however, in the main be restricted to those creatures which pass a considerable amount, or the whole of their time in the water, and which have accordingly been more or less specially modified for that kind of life. Again, in many groups of purely aquatic animals, it is sometimes difficult to say which are true swimmers; a certain number leading an active life when young, and becoming more or less complete fixtures in adult life. We shall commence our survey with the Invertebrate Animals, treating them, however, in a somewhat briefer manner than the Vertebrates, and alluding only to some of the more striking adaptations of certain parts of the body for the purpose of swimming.

All are familiar with those disc-like masses of pellucid gelatinous matter so often thrown up on our sea-beaches, and popularly known as Jelly-Fishes; but to see them in their full beauty we should look down from the bows of a large vessel traversing the warmer oceans. There they may be seen in countless multitudes, extending as far down in the water as the eye can penetrate, and by daylight presenting various tints of pink and purple, while by night they are often phosphorescent. These Medusæ, as they are technically called, are gelatinous creatures shaped somewhat like an umbrella, the "handle" being formed by a mass of thick tentacles hanging down in the water. They swim by the alternate contraction and expansion of the "umbrella" or bell, the diameter of which may considerably exceed a foot. Medusæ belong

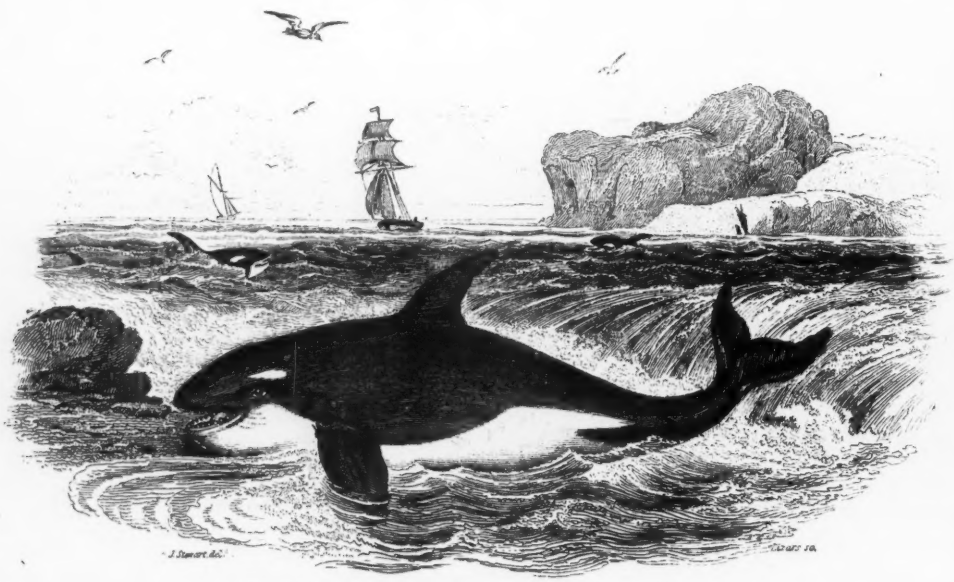

Fig. 1.—The Common Grampus, or Killer Whale.

to that great group of animals known as Zoophytes, which includes the Polypes, Sea-Anemones, and Corals. They afford an example of the so-called "alternation of generations"; being themselves developed by the division of a fixed polype into a number of saucer-like sections, which become free and swim away, and in turn lay eggs, again developing into fixed Polypes, like the original parent.

Our next illustration is taken from the Crustaceans, in which the Lobsters and some of the Crabs are expert swimmers. In the Lobster and Cray-Fishes, where the tail is long, and furnished with five hinged and paddle-like plates, the most rapid motions in the water are effected by suddenly bending the tail beneath the body, and thus driving the creature forcibly backwards by the recoil of the water. Prawns and Shrimps have a similar mode of swimming; but those Crabs which, like the "Fiddlers," are free swimmers have the terminal joints of the fifth pair of legs (and sometimes also those of the three next pairs) developed into flat paddles fringed with hairs. These claws are thus quite different from the pointed claws of the common Shore-Crab. Since Crabs and Lobsters breathe by means of gills, they may be safely regarded as primitive swimmers; those species which, like the Land-Crab, are terrestrial having acquired this habit, and thus having to put up with the inconvenience of keeping their gills constantly moist. We cannot take leave of the Crustaceans without mentioning the Barnacles, as represented by the common Acorn-Barnacle covering the rocks on our coasts, and the Stalked-Barnacle which is more commonly found on the bottoms of ships. In their young state these curious creatures are free-swimming Crustaceans, but after a time, becoming tired of a roving life, fix themselves on their backs by the front of their heads to some solid object, and then develop their well-known shells; the feather-like fan which protrudes from the aperture of these shells being the greatly modified legs, now acting as feelers for the purpose of capturing food. What induced the strange belief that the Stalked-Barnacles underwent a further metamorphosis to appear as Bernacle-Geese, passes ordinary comprehension.

Passing on to the Arachnids (Spiders and Scorpions) and Insects, we find that these creatures, whether aquatic or terrestrial, breathe atmospheric air by means of a system of tubes known as tracheæ, and we are accordingly led to conclude that such of them as are adapted to an aquatic life have acquired this habit. This is especially well shown by the instance of the Water-Spider, which, while agreeing in structure with other spiders, has the limbs fringed and somewhat flattened for swimming, and is in the habit, when diving in the water, of carrying down with it a bubble of air clinging to the hairs of the abdomen.

Among the Insects, the larvæ of many groups in which the perfect animals inhabit the air, such as the Dragon-Flies, May-Flies, and Gnats, are aquatic. Whereas, however, the larvæ of the two former groups are not swimmers, and, therefore, do not come within the scope of the present article, those of the Gnats are endowed in great perfection with the power of swimming. With their large heads and their tapering bodies, these ugly larvæ are probably familiar to most of us, swimming about in ponds and tanks with great agility by a sudden jerking motion of the body, or at intervals suspending themselves head downwards at the surface of the water for the purpose of breathing through a tube situated in the tail. Other insects are aquatic in the adult state. Some of the commonest British examples are the Water-Scorpion (*Nepa*) and Water-Boatman (*Notonecta*), both belonging to the order Rhynchota. These swim by means of the hind legs, which are, however, scarcely fringed in the former, although markedly so in the latter. The Water-Scorpion has two tail-like organs at the end of the body, which, when put in opposition, form a tube through which the creature can breathe without coming quite to the surface. The Water-Boatman, as its scientific name implies, has the curious habit of swimming on its back; when at rest for the purpose of taking in a fresh supply of air the long hind legs are extended nearly at right angles to the body, and thus recall a boatman resting on his oars.

The remaining aquatic insects are the Water-Beetles (Coleoptera), of which there are several families, in all of which both the larvæ and adults are aquatic, although the pupæ are quiescent and lie hidden in holes in the ground. The Water-Beetles are easily recognized by their oval, flat, and boat-like form; some of the species attaining a large size. Most of them swim entirely by the aid of their hind legs, which are greatly enlarged, flattened, and fringed. In the curious little "Whirligig" Beetles (*Gyrinus*), which are so often seen performing their mazy evolutions on the surfaces of ponds and rivers, the reverse of this arrangement obtains, the front pair of legs being enormously elongated, and the second and third pairs very short and paddle-like. The forward motion of these beetles is produced by these short paddles, while the curves are formed by the long fore limbs, which are darted out first from one side and then from the other, so as to change the direction of the body.

The last Invertebrate group we have to mention is the large one of the Molluscs, or Shell-fish. Here by far the greater number of species are aquatic, and breathe by gills, so that we may regard those which are swimmers as being primitively so. Although the adults of the Bivalve Molluscs are either fixed to some solid substance (Oysters), or are merely capable of leaping or turning (Cockles and Fan-shells), yet in their young state all these Molluscs are free swimmers, young oysters being provided with swimming organs composed of delicate hairs. It thus seems probable that these locomotive habits have been transmitted to the young bivalves from originally free-swimming ancestors.

The ordinary Sea Snails (Gastropods), in which the adult creeps on solid surfaces by means of its greatly expanded "foot," are also free swimmers when first hatched, the swimming being effected by means of vigorous flappings of a pair of fins attached near the head. A similar structure and habits have been retained in the adult by the Pteropods, those small translucent Molluscs, of pelagic habits, which are so abundant in some of the northern seas, and afford a considerable proportion of the food of certain species of whales. A well-known writer states that "Multitudes of these little things may now and then be seen on the surface of the water, fluttering with their wings and glittering in the sunshine, to be compared with nothing more aptly than a congregation of the more dressy of the Bombyx Moths."

Although not a true swimmer, the well-known Violet Snail (*Ianthina*) is able to float on the surface of the ocean, either by expanding its "foot," or by developing at certain seasons a peculiar membranous raft-like structure, the cells of which are filled with air, and beneath which the eggs are carried.

A totally different mode of progression through the water is adopted by that group of Molluscs technically known as Cephalopods, in which the head is surrounded by a circle of long prehensile arms, provided with adhesive suckers. This group comprises the existing Cuttle Fishes, Squids, Argonauts, and Nautili, as well as the extinct Ammonites (Fig. 2), and a host of other fossil forms. In

Fig. 2.—Shell of Ammonite.

the free swimming forms, locomotion is effected by the forcible expulsion of a jet of water from a funnel situated near the head, and directed forwards, the result of which is to propel the animal forcibly backwards. Minor aid in swimming is afforded either by expansions of the skin on the sides of the body, or by distinct fins near the tail; while many of these creatures aid their escape from foes by the sudden discharge of an inky fluid during their backward course.

Our notice of Swimming Invertebrates cannot be concluded without mention of those curious marine animals known as Sea-Squirts, and technically as Tunicates—a group usually placed in the neighbourhood of the Molluscs. Although in the adult state many of the Tunicates exist in the form of the bag-like squirts with which many of us are familiar, yet all are free-swimming creatures in the young condition. Moreover, certain of them, like the Salpæ, are pelagic throughout their existence; some of the latter forming chains composed of numerous individuals attached to one another. These Salpæ-chains vary in length, from a few inches to several feet, and swim on the ocean surface with a serpentine movement. The great interest attaching to these Tunicates is that the young exhibit certain structures closely simulating the primitive condition of the spinal column of Vertebrates, and thus suggesting that they are degraded types allied to the original stock from which the Vertebrates themselves are descended. This is very important as regards the derivation of Vertebrates from aquatic animals;—an origin which we should naturally expect, seeing that fishes breathe by means of gills, and are, therefore, presumed to have had aquatic ancestors.

(*To be continued.*)

ON THE SPACE-PENETRATING POWER OF LARGE TELESCOPES.

By A. C. Ranyard.

Unless there is some small star or dimly shining body with a large parallax which has not yet been detected, our nearest neighbour amongst the stars is the double star *a Centauri*. It is situated about thirty degrees from the southern pole of the heavens, and therefore is not visible in England. The two stars together shine with a light which is a little greater than that of a 1st magnitude star, for the larger of these twin suns is ranked by Prof. Gould as being exactly of the 1st magnitude of the photometric scale, and the smaller star is of the $3\frac{1}{2}$ magnitude.

According to this photometric scale of magnitudes, which is now universally used, a star of the 1st magnitude gives just 100 times as much light as a star of the 6th magnitude. Consequently, if the larger star of the pair, which is known as α^2 *Centauri*, were removed to ten times its present distance, it would appear as a star of the 6th magnitude; but this would only be the case if there were no loss of light in travelling from its more distant position. If there were any absorption of light in passing through such a vast distance of space, it might appear smaller and would probably not be visible to the naked eye, for few people see stars with their unaided eyes which are ranked as smaller than the 6th magnitude. According to the photometric scale, a star of any magnitude gives about two and a half times as much light as a star of the magnitude immediately below it. Thus a star of the 6th magnitude gives 2·512 times as much light as a star of the 7th magnitude, and a star of the 7th magnitude gives 2·512 times as much light as a star of the 8th magnitude. Consequently a star of the 6th magnitude gives 6·31 times as much light as a star of the 8th magnitude, and 15·85 times as much light as a star of the 9th magnitude, 39·81 times as much light as a star of the 10th magnitude, and 100 times as much light as a star of the 11th magnitude.

Let us suppose that α^2 *Centauri* was removed to 100 times its present distance, then, neglecting the absorption of light in space, it would shine as a star of the 11th magnitude of the photometric scale, and would only just be visible with a telescope of two and a half inches aperture. This calculation is based on the assumption of Prof. C. A. Young* that, for normal eyes, with a good telescope, the *minimum visible* for a one-inch aperture is a star of the 9th magnitude—an estimate which about corresponds to what might be expected from the diameter of the pupil of the eye.

I have measured the diameter of the pupils of several persons whom I believed to have keen sight, amongst others, the observing eyes of the Rev. T. W. Webb, Mr. Burnham, and the late Dr. H. Draper, and have found that about a quarter of an inch generally corresponds to the maximum dilation of the pupil in viewing faint objects. A telescope of one inch diameter would, consequently, collect about sixteen times as much light as would enter the pupil of the unassisted eye, and ought, with a suitable eye-piece, to show stars giving about $\frac{1}{16}$th the light of a 6th magnitude star just visible to the naked eye. As we have seen above, a 6th magnitude star gives 15·85 times as much light as a 9th magnitude star of the photometric scale. Consequently, neglecting the absorption of light by the lenses, and the reflection from their surfaces, a one-inch telescope ought, with a suitable eye-piece (which collects and sends into the pupil of the eye the whole of the light from the object-glass), to render stars of the 9th magnitude just visible.

The power used with a telescope makes some difference, as it increases the contrast between the brightness of the star and the background on which it is seen—the light of the background being dimmed by magnification, while the star in a good defining telescope is but slightly dimmed by moderate magnification. Thus Dawes found that he could see a star of the 6th magnitude with a telescope having an aperture of only 0·15 inches when a power of $16\frac{1}{2}$ was used. In the case of the one-inch telescope above referred to, the loss of light by absorption and reflection at the surfaces of the lenses seems to be about balanced by the increase of contrast with the background, due to the power employed.

Let us suppose that α^2 *Centauri* were removed to a thousand times its present distance, then, neglecting the absorption of light in travelling through space, it would appear as a star of the 16th magnitude, and would only just be visible with a telescope of 25·12 inches aperture, and if it were removed to 1585· times its present distance, it would shine as a star of the 17th magnitude of the photometric scale, and would only just be visible in a telescope

* See Prof. Young's *Text Book of General Astronomy*, sec. 822.

of 39·81 inches aperture. That is, it would not be visible in the great Lick 36-inch refractor.

These calculations are based on the assumption that there is no absorption of light in passing through great distances of space, and also on the assumption that there is no loss of light in passing through such thick lenses. The thickness of the object-glass of the "Washington" 26-inch refractor at its centre is nearly three inches; thus, the flint glass lens is there 0·96 inch thick, while the crown glass lens is 1·88 inch thick at its centre. Such a thickness more than halves the intensity of the emergent pencil; and the loss of light by absorption in passing through the glass near the centre of the Lick object-glass must be considerable. Exact measures of the absorption of light by such great lenses would be of much interest. We may, however, probably assume with some confidence, that if α^3 *Centauri* were removed to twelve hundred times its present distance it would not be visible in the Lick telescope, even though there were no absorption of light in space; and α^2 *Centauri* is probably larger and brighter than our Sun.*

Stars smaller than our Sun would be lost to sight at smaller distances. Consequently the Milky Way must either be nearer to us than a thousand times the distance of α *Centauri*, or the smallest stars visible in it with a telescope as large as the Washington 26-inch refractor must be larger than our Sun—a supposition at which the mind rebels when we remember the vast size which this would imply for the larger stars evidently involved in or associated with the Milky Way. For example, in the Pleiades group (which we showed reason in the May number for believing to be associated with the Milky Way) there are observable with the eye at the telescope a range of some thirteen magnitudes of the photometric scale, which, translated into ordinary language, means that the larger stars of the cluster give more than a hundred and fifty thousand times as much light as the smaller stars of the cluster.

In the photographs of the Pleiades cluster we have evidence of a range of at least fifteen magnitudes, which means that the larger stars give a million times as much light as the smaller stars, and in the photograph of the Coal-Sack region of the Milky Way, published in the June number, there is evidence of a still greater range of magnitudes. The star α *Crucis*, which is of the 1·3 magnitude, is evidently associated with a dense cluster of small stars, branches from which can be traced far across the Coal-Sack region, and extending to a considerable distance over the Milky Way or into the Milky Way to the north of α *Crucis*. We seem to have in this instance evidence of a range of at least seventeen magnitudes. And the proof of the connection between the large star and the small stars of the cluster is far stronger than as stated by me in the May number. α *Crucis* is a double star with components about 5 seconds apart and there are several small companions that have been observed in the telescope. In the glass photograph sent me by Mr. Russell the spurious disc of the large star is, when examined with a magnifier, seen to contain several small stars forming a cluster about the large one. Indeed, in the plate published in the May number some seven or eight of these small stars may be recognized with a magnifying-glass on the edge of the spurious disc of the large star.

Though the mind may at first be staggered by the conception of stars giving a million times as much light as our Sun, we are not in a position to deny the existence of such vast sun-like bodies. Indeed those who accept the nebular hypothesis as giving the most probable explanation of the origin, or rather of the birth of the planets of the Solar system, must be prepared to believe that there was a time when the Sun had a diameter as large, or nearly as large, as the diameter of the orbit of Neptune. If before these more than geologic ages of radiation into space the surface or photosphere of the solar mass did not shine as brightly as it shines now, it must, at least, have been a nebula with a very definite surface, which, as seen from a distance a hundred times as great as that of α *Centauri* would have presented a disc nearly half a second in diameter. No disc has at present been observed to any star; we may therefore feel some confidence that there is no such vast sun-like body within a distance from us equal to fifty times the distance of α *Centauri*.

In the forthcoming part of the *Old and New Astronomy*, I have shown reason to believe that there is evidence of absorption of light in space, and that we can, from the numbers of the stars of the various magnitudes, make a rough minimum estimate as to the amount of absorption of light in space, due either to a want of perfect elasticity in the light-transmitting ether, or to dark bodies cutting out or obliterating the light in its passage through space. This greatly reduces our idea of the magnitude of the region we can explore with the telescope and with the camera—α *Centauri* would probably be lost to the Lick telescope if it were removed to three hundred times its present distance—and it also greatly reduces our idea of the distance of the small stars of the Milky Way, and of the scale of the galactic system as well as of the nebular system and of the system of clusters, red stars, and bright line stars which are so evidently associated with it.

It is not so very long ago that it was generally taught that the nebulæ were galaxies of stars more or less similar to the Milky Way that surrounds us, but so inconceivably remote as to appear when observed with the largest telescopes like small spots in the heavens. This theory suited the popular taste, and died hard. It involved the assumption that man could explore with the instruments at his disposal a space so immense that the interstellar spaces which we can just measure or guess at, are dwarfed into points beside the distance from which light travels to us.

The theory should have been disposed of by the observations of Sir William Herschel, who noted that many nebulæ are evidently associated with stars, and observed that the smaller nebulæ were distributed over the heavens in a manner which shows an intimate connection between them and the brighter stars. He noted that the nebulæ in the northern heavens were clustered in the pole of the Milky Way, and descended like a canopy on all sides, leaving a dark space or channel separating the nebulous region from the rich stellar region of the Milky Way. Sir William Herschel also fully satisfied himself that "there were nebulosities which are not of a starry nature," and from his observations of diffused nebulæ he formed his well-known hypothesis of a diffused luminous fluid which, by its eventual aggregation, produced stars. But he did not proceed to the legitimate deduction from his observations as to the general distribution of nebulæ, viz.: that nebulæ which are arranged so symmetrically with respect to the stars must belong to the stellar system, and therefore cannot be assumed to lie at immense distances compared with the distance of the Milky Way stars.

* Assuming with Mr. Gore a period of 77 years for this binary, and a parallax of ·75 of a second, the sum of the masses of the components will be 2·14 times the mass of the Sun.

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Sir John Herschel extended the observations of his father to the southern heavens, and showed that there was a similar clustering of the smaller nebulæ on the southern side of the Milky Way, and a similar intimate connection between the distribution of stars and the distribution of nebulæ in the southern hemisphere (see *Cape Observations*, p. 134); but it was not till 1858 that the obvious conclusion from these observations was drawn by Mr. Herbert Spencer in a remarkable paper on "The Nebular Hypothesis," published in the *Westminster Review*. He remarked, "If there were but one nebula, it would be a curious coincidence were this one nebula so placed in the distant regions of space as to agree in direction with a starless spot in our own sidereal system. If there were but two nebulæ, and both were so placed, the coincidence would be excessively strange; what then shall we say on finding that there are thousands of nebulæ so placed? Shall we believe that in thousands of cases these far-removed galaxies happen to agree in their visible positions with the thin places in our own galaxy? Such a belief is impossible."

Mr. Herbert Spencer's paper was not illustrated by charts, and the force of his reasoning was not generally perceived till some ten years afterwards, when Prof. Cleveland Abbé drew attention in the *Monthly Notices* of the Royal Astronomical Society for May, 1867, to the intimate connection between the distribution of nebulæ in space and stars; and Mr. Proctor, in 1869, constructed some charts on an equi-surface projection, which graphically put his readers in possession of the facts and carried conviction to all who read his remarks.

The theory that the nebulæ were distinct galaxies involved the assumption that light can reach us from regions many thousand times more remote than the stream of stars which compose our own galaxy; and it also involved the assumption that the matter of the universe is aggregated into clusters, separated by immense barren spaces, in which we must assume that there are very few luminous stars, and but few dark stars which would absorb light, as well as comparatively very little opaque matter distributed as meteors are distributed in the region of space we are familiar with.

We have evidence that the greater part of the lucid stars belong to the galactic system, but the large proper motion of some stars, taken in conjunction with their small parallax, affords evidence, as Prof. Simon Newcomb has pointed out, that they will in time pass away from our galaxy.* The regions outside our galaxy cannot, therefore, be absolutely barren, but however sparsely luminous stars are distributed through space, if there were no absorption of light in its passage through the ether, and no opaque bodies to blot out the light of distant stars, it would be impossible, as Olbers long ago pointed out, to draw a line in any direction which would not in an infinite universe pass through some luminous star, and the whole heavens ought to shine with the average brightness of such stars.

That the heavens are comparatively dark may, therefore, be taken as proof either that the light-transmitting ether is not perfectly elastic, or that there are numerous dark bodies in space that blot out the light which we should otherwise derive from the more distant parts of the universe.

* Prof Simon Newcomb has shown in his *Popular Astronomy* that making the most liberal assumptions as to the number and masses of the stars of our galactic system, the highest speed which a body could attain if it fell from an infinite distance through such a stellar system would be 25 miles a second, a velocity which is certainly smaller than that of many stars.

THE MAGIC SQUARE OF FOUR.

To the Editor of Knowledge.

Dear Sir,—It may interest some of your readers to know that the deficiency of 32 squares (short of Frenicle's total of 880), mentioned in my letter in the April number of Knowledge, has been supplied by Dr. J. Willis, of Bradford, who has seen Frenicle's collection and given it a careful examination. It appears that Type C (*vide* my article in March number) really has 304 varieties, and not merely 272. I may as well mention at the same time, in justice to Mr. Cram, that it was through an oversight that I obtained only 80 extra squares of this type from him. He meant to have given me seven instead of five, in which case I should have had 7×16 instead of 5×16 extra.

The following analysis of Frenicle's number may, therefore, be now considered as correct:—A, B, D, each 48; C, 304; E, F, each 96; G, I, J, L, each 56; and H, K, each 8.—Total 880.

Whilst writing, I may perhaps be allowed to make two other corrections in my article. The first is a misprint; page 47, first column, the first row of the square (1) should be 1 6 11 16, not 1 6 11 6. Lastly, the first sentence in the last paragraph in the same column is wrong. The four varieties mentioned in the third line are obtained by transposing 0 for 8, and 4 for 12, and *vice versa* (which doubles the number of squares), and then transposing the two centre columns (which again doubles the number), thus making four varieties.

In conclusion, it may be worth while to quote Dr. Willis's opinion, that "it is extremely improbable that other squares of four exist in addition to these 880, as Frenicle appears to have proceeded by finding by trial all those combinations which satisfy the conditions that the sum of the four corner numbers, as well as that of the four numbers in the middle of the square, must equal the normal 34."

T. S. Barrett.

[P.S.—Frenicle's articles, in which his 880 squares occur, may be seen in the British Museum. They are printed in a volume entitled "Divers Ouvrages des Mathematique et de Physique, par Messrs. de l'Academie Royal des Sciences; Paris, 1693." This book is catalogued under the name Frenicle de Bessy, and its library mark is 49 f. 1.]

Mr. P. F. Kendall, F.G.S., wishes us to announce that a Committee has been formed for collecting information with respect to masses of Rock or Boulders distributed over the North-West of England. Mr. Kendall, whose address is 16, Leegate Road, Heaton Moor, Stockport, is acting as Secretary of the Committee, and will be glad to communicate with anyone willing to collect information in their district for the Committee.

THE OBSERVATION OF RED STARS.

By Miss A. M. Clerke, *Authoress of "The System of the Stars," and "The History of Astronomy during the 19th Century," &c., &c.*

"WHY should not stars change in colour as in light?" Baron Von Zach asked tentatively close upon seventy years ago, and the remark gave point to his re-publication, in 1822, of "Lalande's List of Red Stars," the first compiled with the help of the telescope. Now, excellent reasons might be found why such objects should

not vary in tint. If, for instance, Mitchell had hit the truth with his conjecture in 1767, that Antares, Aldebaran, and their fellows glowed with the ruddy light of decaying incandescence, they could obviously be subject only to changes proceeding in the uniform direction of the still further deepening and darkening of their fires. But if such variations as Von Zach anticipated *do* actually occur, then the reasons prohibitive of them must necessarily be invalid. As a matter of fact, do they occur? A great deal of evidence, recently accumulated, tends to show that they do. If this be so, and the conditions producing redness in stars should prove to be fluctuating, it becomes evidently inadmissible to make colour, directly or indirectly, a test of relative standing. What comes and goes cannot be the badge of what is permanent.

Stellar hues depend mainly, perhaps exclusively, upon the composition and extent of stellar atmospheres. Unveiled stellar photospheres would probably all agree in the display of a bluish tinge; but on this point inference and conjecture are our only guides; experience keeps aloof. What is thoroughly ascertained, on the other hand, is that the light which we receive from the stars is a residuum; it is what gets through the sifting apparatus, by various makes and modes of which they are all, without exception, surrounded. The resulting colours differ, just because the sifting apparatus *is* of various makes and modes. The more powerfully it acts, moreover, the redder, as a general rule, are the transmitted rays, because the quick, short, blue and violet vibrations get predominantly entangled and stopped in gaseous envelopes of normal constitution. A corresponding effect is produced in our own atmosphere; hence, the sun at the zenith is nearly white, but shows at the horizon, where selective absorption exerts all its strength, a more or less reddened disc.

More or less. The effect is not always the same. Often barely tinged with orange, at certain times our luminary disappears vividly glowing in crimson or scarlet. In other words, the setting sun is a colour-variable. And why? Plainly because the state and composition of our atmosphere are not always the same. The proportion of water-vapour held in suspension is one inconstant element; another is the amount of floating dust-particles subsiding in still air, or ceaselessly borne onwards by untiring upper currents. And this may help to illustrate the cause of stellar fluctuations in hue. It is, unquestionably, to be found in changes of temperature, of chemical constitution, of electrical condition, or of all three together (for they are pretty sure to be mutually interdependent) taking place in the glowing vaporous envelopes determinant of star-colours.

Their fluctuations must then be evident in the spectrum, as well as to the eye. Spectroscopic change, indeed, is only a re-affirmation, under a different form, of colour-change; the prism analyzing what the eye perceives. Colour sums up, in one subjective impression, the whole series of facts separately stated in each star-spectrum. The subjective impression needs accordingly to be tested and interpreted by the statement of fact. Its differences from time to time, or from person to person, are indicative merely; they may sometimes be admitted as assertions, but they must be unusually well established before they can amount to demonstrations of objective change.

It has long been known that the ruddy tinge of periodical stars, like Mira, lightens and deepens with their gain and loss of brightness; and it has lately been ascertained that remarkable spectral appearances accompany and explain these transitions. In other cases, spectra have been observed to vary independently of any noticeable concomitant effect upon either light or hue. Some exceptional objects, again, show, it would seem, marked changes of colour apart from changes of brightness; and these alone are properly entitled "colour-variables." Such of them as are in systemic connection with neighbouring bodies display a wide prismatic diversity, and both in themselves, and by their instability, give rise to highly intricate considerations; while the phases of solitary colour-variables consist entirely in the paling, or even total disappearance of their customary red hue.

Ostensible instances of this kind are numerous; a few are fairly well-authenticated. Take the eighth magnitude star in Virgo (148 Schjellerup), numbered 352 in the "Espin-Birmingham Catalogue of Red Stars." It shows a finely developed banded spectrum of the third type, and shines by Dunér's estimate in his catalogue of such objects, with a deep red yellow light. Mr. Espin noted its "fine pale red" tint, May 12th, 1885, described by Lord Rosse in 1841 as "scarlet," by d'Arrest in 1866 as "dark red." These, however, are but trifling discrepancies compared with the alleged total absence of colour from the star on May 8th, 1874. Its whitness at that date is attested by one—unfortunately only one—observation of Birmingham's. Any recent notes of its colour which may happen to have been made, would be of special interest for purposes of comparison with the older records. Those relating to the star 90 Schjellerup (Espin-Birmingham 221) are still less mutually reconcilable. But here there is just a possibility—though a remote one—that two different stars, one white, the other orange, may be in question. No shadow of doubt, however, overshadows the identity of a star in Orion (63 Schjellerup) numbered 1888 in the "Copenhagen Catalogue for 1864," which appeared red in 1863, and is now no longer so. Schjellerup perceived in 1870 that the hue he had originally been struck with had vanished. A 7·5 magnitude star in Scutum Sobieski (Schjellerup 214, Espin-Birmingham 544) may with some confidence be pronounced variable in colour. Of its redness, first perceived by Schjellerup, Birmingham could see no trace in repeated observations made in the years 1872-4; twice, indeed, he qualified the object as actually *blue*. But it had reverted, on September 29th, 1889, according to Mr. Espin, to a "pale orange red"; and since its spectrum is a banded one of the third type, it may claim to rank normally—its occasionally blanched aspect notwithstanding—as a red star.

It must here suffice to add one further example from the southern skies. It is that of r Velorum. Dr. Gould, at Cordoba, found the colour of this bright star (5·3 magnitude) so pronounced as in part to baffle estimates of its brightness. But judging from two observations of my own at the Cape, it had completely lost this quality in the autumn of 1888, and my eyes are rather extra-sensitive to the warmer tints of the spectrum. An examination of the star by Mr. Tebbutt in New South Wales, March 3rd, 1891, showed it "to be very slightly tinged with red," though, with a larger instrument (an eight-inch equatorial), three days later, the tinge seemed more decided—"very decided," indeed, "compared with the other smaller, but white stars in the same field of view."* The recovery of colour, however, is still evidently very imperfect. Mr. Tebbutt, one is glad to learn, does not intend to lose sight of this interesting object.

Up to the present, suspected colour-variables have been unaccountably neglected, notwithstanding the great importance both of verifying and of investigating their changes. For they supply what Bacon called "migratory instances," which, in the course of their journeyings from

* Journal of the British Astronomical Association, vol. I., p. 423.

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one class to another, may be expected to prove instructive as to the essential characters of each. The very fact that such migratory instances are to be met with is in itself significant. It assures us, at any rate, that red and white stars are not the products of widely separated epochs of cosmical history. But besides this piece of negative information, much positive intelligence should be derivable from them. The co-ordination of spectral and colour-change has never yet been satisfactorily accomplished. The two kinds of variation are so far united that although the former might conceivably take place without the latter, the latter inevitably involves the former. Thus a star spectrum might, although it is unlikely that it would, vary fundamentally in character without any attendant variation in tint. This would be the case, for example, if emergent bands or lines were so situated as to be complementary one to the other. And in point of fact, relatively trifling modifications of colour appear to have been concomitant with the striking spectral changes detected by Mr. Espin in R Coronæ and R Scuti. But colour-variation *must* be explicable, so to speak, by spectral variation. Enquiries on this head are superfluous, their upshot being self-evident. What needs to be investigated is the form and manner of a correspondence which unquestionably exists. In this direction next to nothing has been done; to the questions that suggest themselves no answers are forthcoming; yet by their means, if at all, the enigma of star-colours ought to prove soluble. A thorough examination of a single colour-variable in its slowly alternating red and pale phases could hardly fail to disclose the essential condition of the peculiarity of its light. What supervenes, one desires to know, in the atmosphere of that star, now to blanch, and again to flush its rays? Are they subtracted from by additional absorption, or reinforced by special but transient emissions? Is continuous absorption included among the elements of change? That is to say, does the dusky veil thrown over the upper part of the spectrum appreciably lift or lighten with the paling of colour? The providing of definite replies to these definite queries would in itself make a solid beginning of knowledge as regards the cause of redness in stars. But they can only be provided by the persevering exertions of some one competent observer. Such disjointed notes of colour as have been hitherto visually recorded are of little use except in the way of suggestion. They have furnished the means of constructing a working list of objects more or less vehemently suspected of change, and thus served their main purpose of prescribing the aim, and limiting the scope, of a fresh series of more concentrated operations. Half-a-dozen red stars assiduously watched would probably be found more genuinely communicative than hundreds passed in review, and then abandoned until perhaps recovered after a decade or two by some other collector of celestial curiosities, whose perplexities at certain incongruous results of his search would remain as unprofitable as those of his predecessor. But the half-dozen stars chosen for detailed scrutiny should be tested spectroscopically and spectrographically, no less than visually. The photographic delineation of the spectra of small red stars would no doubt demand large instruments; yet without it the enquiry would be lamentably incomplete. Indeed, the tell-tale modifications looked for would be more likely to present themselves in the higher than in the lower reaches of the spectrum. From its exceptional brightness among colour-variables, *r* Velorum might be singled out as a particularly tempting subject for investigations of the kind described, were not astro-physical observers and apparatus equally scarce in the southern hemisphere.

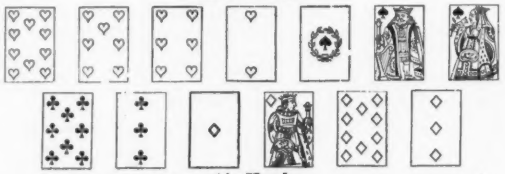
Whist Column.

By W. Montagu Gattie, B.A.Oxon.

Refusing to Overtrump.

CASES frequently arise in which it is not advisable to overtrump. The following hand furnishes a simple illustration.

Hand No. 22.



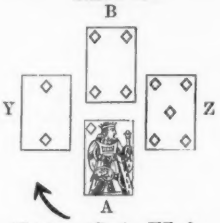
A's Hand.

Score—Love all.

Z turns up the three of hearts.

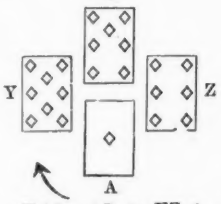
Note.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

Trick 1.



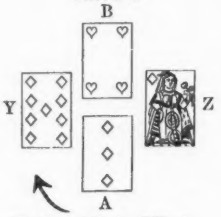
Tricks—AB, 1; YZ, 0.

Trick 2



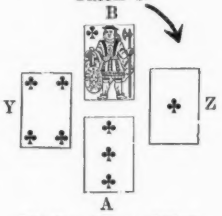
Tricks—AB, 2; YZ, 0.

Trick 3.



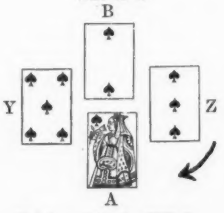
Tricks—AB, 3; YZ, 0.

Trick 4.



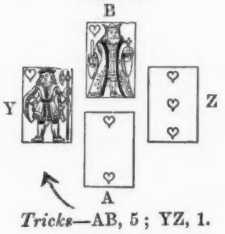
Tricks—AB, 3; YZ, 1.

Trick 5.



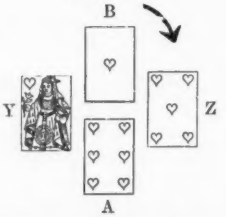
Tricks—AB, 4; YZ, 1.

Trick 6.



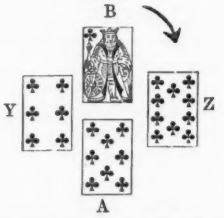
Tricks—AB, 5; YZ, 1.

Trick 7.



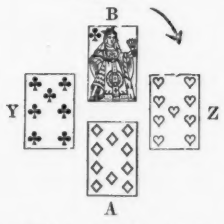
Tricks—AB, 6; YZ, 1.

Trick 8.



Tricks—AB, 7; YZ, 1.

Trick 9.



Tricks—AB, 7; YZ, 2.

Note.—A discards his losing diamond instead of overtrumping, and so secures the game. He might infer from Z's nine of hearts that B holds the eight; but the nine may be a false card (as is indeed the fact), and in that case Z will save the game if he has the best spade after three rounds, unless A allows him to win this trick. For, after overtrumping, A cannot prevent YZ from making either the knave of spades or the knave of diamonds as well as the eight of trumps.

Tricks 10 *to* 13.—Whatever Z leads, A makes the remaining tricks, and

AB Score Five by Cards.

A's Hand.	B's Hand.
H.—10, 7, 6, 2.	H.—Ace, Kg, 4.
S.—Ace, Kg, Qn.	S.—10, 6, 2.
D.—Ace, Kg, 10, 3.	D.—7, 4.
C.—8, 3.	C.—Kg, Qn, Kn, 5, 2.
Y's Hand.	**Z's Hand.**
H.—Qn, Kn.	H.—9, 8, 5, 3.
S.—8, 7, 5.	S.—Kn, 9, 4, 3.
D.—Kn, 9, 8, 2.	D.—Qn, 6, 5.
C.—9, 7, 6, 4.	C.—Ace, 10.

This is purposely given as a very simple example of the disadvantage of overtrumping in like circumstances, and A's proper play may seem to many readers too obvious to need demonstration, since it is clear that, after discarding his diamond, he must win every other trick. Yet it is surprising how often such opportunities are missed in actual play. Next month we hope to give a somewhat more difficult illustration of the same principle.

Chess Column.

By C. D. Locock, B.A.Oxon.

To Correspondents.—Communications for this column should be addressed "*Cintra, Hawkhurst, Kent*," and posted *before* the 10th of each month.

Solution of Problem No. 1 (*by W. E. Bolland*) :—1. K to K3, and mates next move.

Correct Solutions from :—Alpha, T. E. Kerrigan, T. Hurley, R. T. M., Giu. Pianissimo, K., J. Landan, F. A., A. G. Hansard, T. A. Earl, T. K. Bentley, R. W. Houghton, F. W. Sharp, White Knight, A. J. Luisham, G. F., J. Humble, A. N. Brayshaw, E. B., Betula, C. S., A. C. L. Wilkinson, M. B. (Jesmond), R. A. Layton, C. T. Blanshard, J. Johnston, J. G. Ellis, A. Rutherford, T. H. Billington, and T.—(30 correct; 2 incorrect.)

H. S. B.—Not quite right. If 1. K to B2, Q × R, and there is no mate.

F. de F. (Perugia).—After 1. K to B4, Q × R; 2. Kt × Qch is not mate.

G. F.—Thanks for problem, which we insert; it is quite good enough. Owing to a misprint in your key-move we thought at first that there must be two solutions.

J. G. Ellis.—Quite right, of course. Seeing the win of the Queen we looked for nothing else.

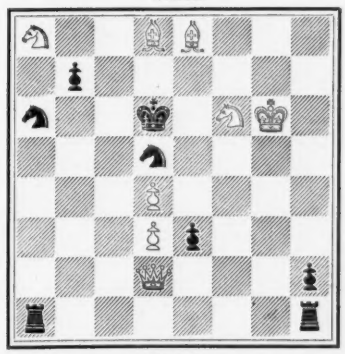
T.—Notice in July number reads, "*posted before* the 10th," which is, of course, identical with "on or before the 9th." Problem enclosed is hardly legible; and if legible, unsound.

H. C. H. and J. Taylor.—Too late for acknowledgment with the rest; will credit next month if no objections are raised.

PROBLEM (No. 2).

By G. F.

White.



Black.

White to play, and mate in three moves.

The attention of solvers is called to the rule that in the case of *three-move* problems all *White's second moves* should be sent. Competitors' scores will be published next month.

Game played, July 1st, in the Divan Tournament :—

Ruy Lopez.

White. (N. Jasnagrodsky.)	Black. (J. Mortimer.)
1. P to K4	1. P to K4
2. K to KtB3	2. Q to KtB3
3. B to Kt5	3. Kt to B3
4. Castles	4. Kt × P
5. P to Q4	5. B to K2
6. R to Ksq (*a*)	6. Kt to Q3
7. B × Kt (*b*)	7. KtP × B (*c*)
8. Kt × P	8. Castles
9. QKt to B3	9. P to B3
10. Kt to Q3	10. Kt to B2
11. B to B4	11. P to Q4 (*d*)
12. Kt to R4 !	12. B to Q3
13. QKt to B5	13. R to Ktsq
14. P to QKt3	14. R to Ksq
15. Q to B3	15. B to Q2 (*e*)
16. R × Rch	16. Q × R
17. R to Ksq	17. Q to QBsq
18. P to KR3	18. B to B4 (*f*)
19. Q to Kt3 (*g*)	19. P to Kt4
20. B × B (*h*)	20. P × B
21. Kt to R4	21. Q to Bsq ! (*i*)
22. Q to K3	22. R to Kt2
23. P to KKt4 (*j*)	23. B to Kt3
24. P to KB4	24. B × Kt
25. P × B	25. P × P
26. Q × P	26. Kt to Kt4
27. K to R2 ? (*k*)	27. R to K2
28. R to KBsq ?	28. Q to R3
29. Q to Kt3 (*l*)	29. R to K7ch
30. R to B2	30. R × Rch
31. Q × R	31. Q × Pch
Resigns.	

XUM

NOTES.

(*a*) 6. Q to K2 is now more usually played, but against correct play it yields no advantage.

(*b*) 7. P×P is perhaps better. If then 7. . . Kt×B, 8. P to QR4, recovering the piece.

(*c*) 7. . . QP×B leads to an even game. Black probably wished to avoid the exchange of Queens, but gets thereby a rather cramped game. White's next move is better than P×P, for Black could then, after Castling, free his game by P to KB3.

(*d*) This leaves a weak point at QB4 to be occupied by the hostile Knights. He might try instead B to Q3 at once (White threatens B×P).

(*e*) In order to make room for the Queen at Bsq. Kt to Rsq also seems feasible, leaving a diagonal for the Queen to escape by, in case White exchanges Rooks, and ultimately developing by Kt to Kt3.

(*f*) Just in time to prevent his game being blocked by P to KKt4.

(*g*) White so far has played with excellent judgment, but has nothing more to do at present. His only chance of attack lies in working his Queen on to the QR file. The move actually made is cleverly taken advantage of by Mr. Mortimer to drive the QKt out of play; but *vide* note (*h*).

(*h*) If 20. P to KR4, P to KR3 (best); 21. P×P, RP×P; 22. R to K3! K to Bsq; 23. B×B, P×B; 24. R to B3! B to K5 (If . . . P×Kt; 25. R×B); 25. R×P, P×Kt; 26. Kt×P, threatening to win by Q×R, Kt to Q7ch, and R×Ktch, and threatening also R×P or Q×P or Q to Q6ch according to circumstances. In any case White must get at least three Pawns for the piece sacrificed, and would probably win in actual play.

(*i*) With a view to R to Ksq, which White proceeds to stop. The move also frees his Knight.

(*j*) By this and his next move (which is of the nature of a blunder) White unnecessarily compromises his position. He should bring the QKt into play. Mr. Mortimer now takes up the attack in vigorous style till the end.

(*k*) K to Kt2 seems much better. Black now, noticing the position of the White Knight, is content to offer the exchange of Rooks. White, however, could still draw by accepting it. His next move is speedily fatal.

(*l*) 29. Kt to B3 would prevent the immediate catastrophe, but Black would win after 29. . . Q×Pch; 30. K to Ktsq, R to K6, &c. Again, if 29. . . . Q×BP, R to K7ch; 30. K to Kt3, R to K6ch! and wins easily.

KNIGHTS AND BISHOPS.

(*Continued from p.* 140.)

1. The first point to be considered, then, is extent of range. In this the superiority of the Bishop seems at first sight overwhelming. A Bishop commands a maximum of thirteen squares, and a minimum of seven; a Knight's maximum is eight, and its minimum only two. This superiority, however, is subject to important limitations. It should be noticed, for instance, that the Bishop commands its maximum number of squares, only when placed on one of the *four* centre squares; while a Knight commands its maximum when placed on any one of the *sixteen* centre squares, and this too regardless of obstacles. Moreover, in the earlier stages of the game a Bishop can very rarely be posted with advantage in the centre of the board; and unless this is so, its maximum is at once reduced to eleven squares.

2. A Knight can be brought to command any square on the board; a Bishop being, of course, limited to half the total number. The Knight's advantage here is especially prominent in a blocked position, or when Pawns have to be attacked in the end-game.

3. Nothing can prevent a Knight from commanding any square within its range. A Bishop, on the other hand, except in the end-game, is hampered even more by his own Pawns and pieces than by those of the other side; so much so, that a Bishop may be sometimes reduced to a state of total inactivity. But there is no imprisoning a Knight possessed of ordinary prudence.

Now comes a most important consideration. It is well known that a minor piece should generally be supported by a Pawn; and in the case of a Bishop, the very Pawn which supports it shuts it out from retiring in that direction, and very often from communication with the other wing, which should always, when possible, be kept open. For this reason the best position on the board for the King's Bishop is QKt3. A loophole for escape may be opened by P to QB3, and the Bishop, being defended by a *Rook's* Pawn, is not shut out from commanding any square within its range.

(*To be continued.*)

The British Chess Magazine for July contains a portrait of Buckle, the historian, with a sketch of his chess career illustrated by some of his games. Perhaps the most attractive feature of the number is a very readable review of Mr. Gossip's latest. A Problem Tourney with some novel features is announced.

A Tournament has been in progress some weeks at Simpson's Divan. The first prize lies between Messrs. Loman and Van Vliet; Messrs. Bird and Mortimer should take the third and fourth prizes. The other competitors are Messrs. Lee, Muller, Tinsley, Gossip, Fenton, and Jasnagrodsky.

A match of seven games up has been arranged between Messrs. Blackburne and Gunsberg. The *locale* is not yet decided on.

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